RADIOLOGY

A MONTHLY JOURNAL DEVOTED TO CLINICAL RADIOLOGY AND ALLIED SCIENCES

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CONTENTS

SYMPOSIUM ON RADIATION UNITS. RADIATION UNITS AND RADIATION INSTRUMENTS. *H. M. Parker, M.Sc., F. Inst. P.* 629

SURFACE DOSE. *Elizabeth F. Focht* 637

INTENSITY AND ABSORBED DOSE RATE. *John S. Laughlin, Ph.D.* 646

RADIATION DOSIMETRY OF INTERNALLY ADMINISTERED BETA RAY EMITTERS: STATUS AND PROSPECTS. *Leonidas D. Marinelli, M.A.* 656

PANEL DISCUSSION ON LOW-BACK PAIN. OBJECTIVES OF THE PREPLACEMENT X-RAY INVESTIGATION OF THE LOW-BACK AREA. *John R. Winston, M.D., and Robert D. Moreton, M.D., F.A.C.R.* 664

RADIOLOGIC CONSIDERATIONS IN PREPLACEMENT EXAMINATIONS OF THE LUMBAR SPINE. SUMMARY OF FOUR THOUSAND CONSECUTIVE CASES. *Robert D. Moreton, M.D., John R. Winston, M.D., Douglas E. Bibby, M.D., and Claude Williams, M.D.* 667

MEDICOLEGAL RADIOLOGY. *Charles L. Ewing, M.D.* 673

SPONDYLOLISTHESIS WITHOUT ISTHMUS DEFECT. *R. M. Potter, M.D., and J. R. Norcross, M.D.* 678

ROENTGENOLOGIC BONE CHANGES ENCOUNTERED IN FROSTBITE, KOREA 1950–51. *Harold A. Vinson, Lt. Col., M.C., and Richard Schatzki, M.D.* 685

VENOUS ANEURYSMS OF THE MEDIASTINUM. *Ted F. Leigh, M.D., Osler A. Abbott, M.D., James V. Rogers, Jr., M.D., and Brit B. Gay, Jr., M.D.* 696

A COMBINATION FILM CHANGER FOR RAPID OR CONVENTIONAL RADIOGRAPHY. *Leo G. Rigler, M.D., and John C. Watson, R.T.* 706

HODGKIN'S DISEASE AND AMYLOIDOPATHIA. *A. Hochman, M.D., and P. Czerniak, M.D.* 716

PYELOGRAPHY FOR THE DIAGNOSIS OF LESIONS OF THE BODY AND TAIL OF THE PANCREAS. *George W. Chamberlin, M.D., and Irving Imber, M.D.* 722

HYALURONIDASE IN INTRAMUSCULAR EXCRETORY UROGRAPHY. *Herbert L. Warres, M.D., and Albert C. King, M.D.* 730

HAND-OPERATED BARIUM PUMP ASSEMBLY FOR EXAMINATION OF THE COLON. *Henry C. Crozier, M.D.* 734

CEREBELLAR SARCOMA WITH BONE METASTASES. *Walter H. Kehler, M.D., and Erwin Beck, M.D.* 736

EDITORIAL: NEW UNIT OF DOSE. *Robert R. Newell, M.D.* 741

ANNOUNCEMENTS AND BOOK REVIEWS. 743

RADIOLOGICAL SOCIETIES: SECRETARIES AND MEETING DATES. 747

ABSTRACTS OF CURRENT LITERATURE. 751

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Symposium on Radiation Units

Radiation Units and Radiation Instruments[1]

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THE FIELD OF radiation dosimetry involves a close relationship between *units* and *instrumentation* that is similar to the proverbial chicken and egg relationship, in which it is difficult to state unequivocally which came first. This duality has had a profound influence on the historical development of the field. It also justifies the presentation of the background for this symposium in a way that intermingles units and instruments. It is to be understood that the principles of instrumentation, rather than the detailed design, construction, and operation of specific apparatus, will be considered.

BASIC CHOICE OF MEASURING METHOD

A *unit* is the specific magnitude of a quantity, set apart by appropriate definition, which serves as a basis for comparison or measurement for other quantities of the same nature. Whenever a phenomenon of science is discovered, a measuring system, and eventually a unit, develops upon the basis of some conveniently observable effect of the new agent. It is not uncommon to find that familiar agents can be satisfactorily measured, for different applications, by more than one method. In the case of electric current, for example, the scientific unit is based on the magnetic effect of the current, whereas the practical unit is based on the unrelated electrochemical deposition effect. It should be neither surprising nor discouraging that in the younger field of radiology there should have been a multiplicity of units.

In the early days of radiology, many of the newly discovered effects of ionizing radiation served as measuring methods, often with associated arbitrary units. The calorimetric method dates back to 1897. Chemical methods and fluorescence or scintillation were used in the first years of the present century. One of the earliest dose systems was founded on the coloration of the Sabouraud and Noiré pastilles. The photographic method, the primary means of detection, was made reasonably quantitative as early as 1905. In the following decade, radiation effect on electrical resistance was used A wide variety of biological effects was scrutinized for dosimetry use. Ionization in gases gained an early lead. The first formal statement of an ionization unit was apparently that of Villard in 1908, defining a unit quantity of x-radiation as that which by ionization liberates one electrostatic unit of electricity per cubic centimeter of air under normal conditions of temperature

[1] Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13–18, 1953. Work done under contract W-31-109-Eng-52 to the Atomic Energy Commission.

and pressure. This is still the elementary interpretation of the present-day "roentgen."

The reasons for preference of the ionization method in air are of importance in the whole development of radiological units. These are essentially as follows:

(1) The existence of a saturation potential in a gas-filled chamber provides a stable method of relating "ions produced per unit volume" to a measurable electric charge or potential or, for steady state, to electric current.
(2) Such electric potentials or currents can be measured with precision, over a very wide range.
(3) The range over which radiation intensity is linearly related to ion current is very large.
(4) Dry air is a universally available medium of essentially constant composition over the earth's surface.

Standard instrumentation was developed to measure the exposure at a point in a narrow pencil of rays from an x-ray tube. This was the familiar parallel plate or "free-air" chamber. The complications due to incomplete utilization of electron tracks originating in the beam, and to secondary effects from the walls of the chamber, were recognized and resolved by practical means.

The first definition of the "roentgen" (1928)—"the roentgen shall be that quantity of x-radiation, which, when the secondary electrons are fully utilized, and the wall effect avoided, produces in one cubic centimeter of atmospheric air, at 0° C. and 76 cm. mercury pressure, such a degree of conductivity that one e.s.u. of charge is measured under saturation conditions"—was, in effect, a generalization of the description of the particular standardizing instrument.

Concurrently, it was appreciated that the conditions of exposure in radiology required other measuring equipment. A voluminous literature appeared on the topic of thimble chambers, and how to make them give results in accord with the free-air chamber. The concept of an air-equivalent chamber wall developed. Practical solutions were all empirical, and valid only over a limited range of x-ray energy.

A completely different approach to dosimetry was taken in the 1930's, with the statement of the Bragg-Gray Principle. This provides a method of determining the energy absorption of radiation in a medium (usually solid for convenience) in terms of the physical measurement of the ionization in a *very small* gas-filled cavity in the medium at the locus of interest. Numerically,

Energy absorbed per unit volume of medium = (ionization per unit volume of cavity) $\times W \times \rho$

where

W = average energy lost by a secondary electron in producing one ion pair. This is normally considered to be a constant, equal to 32.5 electron volts.
ρ = ratio of the electron-stopping power of the medium and the cavity gas, a determinable physical constant.

The Principle has two familiar limitations:

(1) The depth of the cavity must exceed a certain transitional layer for secondary electron equilibrium in the medium.
(2) The cavity size must be small enough to cause negligible loss of energy of any secondary electron track crossing it. Incidentally, the *direct* absorption of the incident radiation in the cavity will be negligible.

This leads to a new kind of instrumentation—a thimble chamber in which the wall material is the important medium and the nature of the ionized gas is subordinate. Gray himself proposed that a new dosimetry unit should be based on such chambers with a pure substance wall, as for example *carbon*. No international agreement was reached on this point, and a compromise utilization of the Principle in terms of an air-wall chamber with an air-filled cavity was built into the revised definition of the roentgen (1937): "The roentgen shall be that quantity of x- or gamma-ray radiation

such that the associated corpuscular emission per 0.001293 gm. of air produces, in air, ions carrying 1 e.s.u. of quantity of electricity of either sign."

Now the free-air chamber was no longer the sole basic instrument for dose determination; it became only one experimental form of a wider family of measuring instruments. Two fundamental improvements were involved. First, it was no longer necessary to restrict primary measurements to narrow pencils of rays, which are difficult to define at high energies. Secondly, the revised method can handle radiation incident on the receptor from all directions. The Failla extrapolation chamber was also placed in proper perspective as one convenient laboratory method of obtaining a cavity small enough to satisfy the Bragg-Gray Principle.

In passing, one should also mention the use of the extrapolation chamber for dose determinations at the interface of two dissimilar media, where the depth of an attempted Bragg-Gray cavity does not exceed the transitional layer. Bone to soft tissue and skin to air are the interfaces of primary radiological concern. The subject of surface dose will be specifically considered by Miss Focht in the following paper.[2]

In retrospect, it is perhaps well that Gray's proposal was not accepted. The limitation (2) is highly restrictive for low-energy radiation except when wall material and contained gas are identical in atomic composition. Also, carbon would have been an undesirable material for later extension to neutron dosimetry. Nevertheless, the continuation of a radiation unit based on the intrinsic properties of air as an absorbing medium was perhaps a mistake. The radiologist has no interest in the specific absorption process in air; he is vitally concerned with absorption in tissue. In roentgen dosimetry, except in the case of the free-air chamber, the standardizing laboratory has to produce a wall material equivalent to air. It is no more difficult to produce a material equivalent to tissue, or at least to some agreed form such as soft tissue.

The immediate physical events that take place when radiation is incident on tissue can be fully described, and the radiotherapist is cognizant of the subsequent clinical reactions. The intermediate stages are matters of interest to a variety of scientific disciplines. This is indicated in rather arbitrary fashion in Table I.

TABLE I: INDIRECT ACTION OF RADIATION

Field of Science	*Interaction Considered*
1. Physics	Ionization produced in water
2. Physical Chemistry	Decomposition of water forming free radicals
3. Physical Chemistry and Biochemistry	Primary reaction of radicals with chemical substances in cells
4. Biochemistry	Subsequent chemical reactions in cells
5. Radiobiology	Effects of biochemical changes on growth of cells
6. Radiotherapy	Integrated effect of cellular changes on welfare of the organism

Until the intermediate processes can be more fully elucidated, it has been generally accepted that radiation dose (or absorbed dose) shall be specified in terms of energy absorption per gram of tissue at the locus of interest.

The actual utilization of absorbed energy in tissue is a complex process. For photonic energy, the absorbed portion appears first as kinetic energy of secondary electrons, which is then shared to produce ionization and atomic or molecular excitation. Each of these energy components is then further degraded to produce either increased intrinsic energy (*e.g.*, permanent chemical change) or heat (*e.g.*, increased molecular motion).

The partition between ionization and excitation is known to be approximately equal for the case of simple gases such as oxygen and nitrogen. For the more complex molecules of tissue, it may well be different. It is a matter of convention only that the total energy absorption per gram of tissue is chosen as the basis for dose; this is the quantity that comes from the Bragg-Gray Principle through the use of the constant W.

[2] See page 637.

Table II: PRIMARY ABSORBED DOSE MEASUREMENT

Receptor	Measurement Method	Function
1. Bragg-Gray chamber. Wall: tissue-equivalent. Gas: air	Ion current	Any radiation if equivalence is valid
2. Bragg-Gray chamber. Wall: tissue-equivalent. Gas: tissue-equivalent	Ion current	Avoidance of restricted dimensions of Class 1
3. Bragg-Gray chamber	Proportional region	Measurement of heavy particle ionization in the presence of photons or of electrons
4. Tissue-equivalent mass	Calorimetry	[Theoretically sound / Limited in practice]

BASIC INSTRUMENTATION METHODS

Basic instrumentation is indicated in Table II.

Class 1 refers to a receptor in the form of a "cavity" chamber, such as a thimble chamber or extrapolation chamber, whose wall is "equivalent" to the relevant tissue with respect to response to the particular type of radiation used, and over the range of radiation energy involved. Effective equivalence is easily assured when the interaction between radiation and tissue is essentially confined to the Compton effect, as for hard gamma rays.

Since the cavity dimension limitation is restrictive for low energy, it may be desirable to overcome it by use also of a "tissue-equivalent" gas in the cavity. This is Class 2 in Table II.

Class 3 refers to the operation of a cavity chamber in the proportional counting region in which ionization due to photons or primary electrons is suppressed in favor of the much denser ionization produced along tracks of heavily ionizing particles such as protons. It is a basic method for measuring fast neutron irradiation in terms of its secondary corpuscles.

Class 4 is a method applicable in principle to any type of ionizing radiation. Energy absorption is determined by some type of calorimetry. The method differs from the other classes in that energy going into permanent chemical change rather than sensible heat is not recorded. This difference is presumably insignificant with current accuracy in dosimetry.

The unit of measurement in all these cases will be ergs per gram of tissue or some practical unit which is a multiple of this.

SECONDARY INSTRUMENTATION METHODS

For photonic irradiation, secondary instrumentation is indicated in Table III.

TABLE III: BASIC SECONDARY METHODS

(Primary for roentgen dosimetry)

Type	*Function*
1. Open-air parallel plate chamber.....	Narrow beams of x-radiation; conventional energy range
2. Pressure parallel plate chamber.....	Narrow beams—x-rays, gamma up to ~3 mev
3. Bragg-Gray chamber (air-equivalent)...	Primary measurement of roentgens for wide beams

These methods need no further elaboration. They are the ones that are basic to conventional dosimetry in terms of roentgens. The point to be made is that if we wholeheartedly accept the energy-absorbed dose concept, measurements in roentgens become relegated to secondary status *in principle*. The fundamental practical importance of standardization by these methods will probably be unaffected in the present state of dosimetry.

PARTICULATE RADIATION

With a dosimetry for photonic radiation founded on the Bragg-Gray Principle, it is logical that neutron dosimetry should follow the same pattern. The method is the same for fast neutrons, with the secondary particles being proton tracks with appropriate different values for W and ρ. The instrumentation calls for a tissue-equivalent wall, which in this case must be properly balanced for hydrogen content, in particular. The cavity size requirement is severe, and good experimental work calls for the use also of a tissue-equivalent gas. These methods are included in Classes 2 and 3 of Table II.

For thermal neutrons, mixed secondary radiation is developed in a chamber wall—

gamma-rays from the capture of neutrons predominantly by hydrogen atoms, and protons by the $N^{14}(n, p)C^{14}$ nuclear reaction. The Bragg-Gray instrumentation in this case is rather academic; an acceptable tissue equivalent has to simulate tissue composition so closely that in effect it has to *be* tissue for the chamber wall (Failla, for example, has used cheese). Furthermore, the total energy absorption dose so obtained is of little value in radiology, because the biological effectiveness of the two components is different.

Gray, Rossi, and other leading experimenters in this field have used multiple chambers with different atomic composition, so that the dose component of each type of secondary radiation can be computed.

The case of beta radiation or of electron beams is of special interest because it indirectly led to the use of a variety of arbitrary units. The measurement can proceed on the Bragg-Gray Principle, but in effect it can be made with chamber materials or contained gas of any convenient light elements. Essentially only the electron density is of importance in establishing or correcting to tissue-equivalent absorption.

The effective ionizing agents for both photons and beta-rays are electron tracks. It is plausible, therefore, to attempt to measure dose in the same units for both. Since radiology had long used the roentgen, the particulate radiation case was converted to some form of equivalent roentgen.

The roentgen is essentially a constant energy absorption dose of 83.8 ergs per gram in air.[3] In pure water, fairly high-energy photons give 93 ergs per gram per roentgen. Either of these numbers gives a logical numerical basis for an equivalent roentgen. In any case, the actual energy absorption per roentgen of soft tissue or fat is quite variable, say between 40 and 100 ergs per gram for different photon energies.

[3] This assumes the constancy of W; without this assumption, the whole concept of the Bragg-Gray Principle has to be re-examined.

After 1948, there was fairly general agreement that the *rep* (roentgen equivalent physical) was as convenient a nomenclature as any, and that the value 1 rep = 93 ergs per gram was the most acceptable. At the recent International Congress of Radiology, it was agreed to avoid confusion between the various reps and other equivalents, by defining an absorbed dose as follows:

> Absorbed dose of any ionizing radiation is the amount of energy imparted to matter by ionizing particles per unit mass of irradiated material at the place of interest. It shall be expressed in "rads."
>
> The *rad* is the unit of absorbed dose and is 100 ergs per gram.
>
> The choice of an "equivalent roentgen" that differs from the physical statement of dose only in the matter of decimal place will facilitate the utilization of data obtained by those who prefer to work in ergs per gram and those whose experience is with a radiological unit. It will be in the best interests of radiology if those who have become accustomed to the use of the rep will make a prompt transition to the rad. In the majority of the cases, the limited accuracy of dosimetry hardly justifies the use of the formal multiplier 1 rep = 0.93 rad in this transition.

MIXED RADIATION

Relative biological effectiveness (RBE) measures the efficiency of any particular type of radiation in producing some specific biologic effect, relative to some arbitrary standard radiation. In the available literature, standards have usually been either "ordinary" x-rays (*e.g.*, 200 kv.) or the gamma-rays of radium. It is recognized that the elementary theory of relative effectiveness hinges on the specific ionization or average linear energy transfer. Failla has recently proposed, therefore, that the reference radiation should be defined in terms of specific ionization. He suggests a standard of average specific ionization of 100 ion pairs per micron of water, which corresponds with "ordinary" x-rays. In addition, it must be appreciated that much of the earlier work on RBE was done with one or more of the doses specified in roentgens. With the more general acceptance of absorption dose, it will be clear that radiations tested for

RBE will all be measured in *rads* (or ergs per gram) in the tissue of interest.

Under certain simplified conditions, it is permissible to add exposures to mixed radiation by converting the relevant physical doses in rads to equivalent biological doses by operating on them by the appropriate RBE factor. This is best described as a mathematical operation:

"Biological" dose in *rems* =
(physical dose in rads) × RBE

The "rem" is then essentially a radiation unit which can be defined as follows:

> The rem is the quantity of any ionizing radiation such that the energy imparted to a biological system (cell, tissue, organ, or organism) per gram of living matter by the ionizing particles present in the locus of interest, has the same biological effectiveness as one rad of x-radiation with average specific ionization of 100 ion pairs per micron of water in the same region.

This definition is modified from the original one to preserve the same general meaning, with inclusion of the rad and the new agreement on arbitrary standard radiation.

In some fields where mixed radiation is inevitable, and notably in radiation protection, the "rem" concept is invaluable. It operates through a scale of relation such as:

Radiation	Relation
X-rays, gamma-rays	1 r ≈ 1 rad = 1 rem
Electrons (β rays), positrons	1 rad = 1 rem
Thermal neutrons	1 rad = 5 rem
Fast neutrons, protons	1 rad = 10 rem
Alpha particles	1 rad = 10 rem[4]
Massive ionizing particles	1 rad = 20 rem

or, in terms of specific ionization:

Av. specific ionization of ion pairs per micron of water	RBE or rem/rad ratio
100 or less	1
100 to 200	1 to 2
200 to 650	2 to 5
650 to 1500	5 to 10
1500 to 5000	10 to 20

For most clinical radiological situations, the RBE or rem/rad ratio is not known accurately enough, under the particular conditions of exposure. It is, of course, a grave error to accept the rem as an unequivocal unit for a given radiation type, since many other parameters besides specific ionization affect the appropriate value of RBE.

For this reason, it is proper to re-emphasize that the rem can be regarded as a convenient shorthand notation for management of specific mixed radiation cases, rather than as an "accredited" radiation unit.

DIRECT DETERMINATION OF ENERGY ABSORPTION DOSE

Under the present concept of dose, it is attractive to attempt a direct physical determination of the energy absorption. With photonic irradiation, for which the rate of energy absorption per unit mass of tissue is low, there are major experimental difficulties. Those measurements in which the rate of energy transfer is increased by absorption in a heavy metal have only limited application in dosimetry.

There are some special cases in radioisotope applications in which the energy absorption dose can be computed reliably. At any point in tissue which is surrounded by a range thickness of material containing a uniform distribution of radioactive material, the dose can be written down from the self-evident equation—

Energy absorbed per gram = energy emitted per gram
= (number of particles emitted per gram) × (average energy of the particles)

The method is especially valuable with emissions of alpha particles or of beta particles unaccompanied by gamma rays. How this basic dosimetry method can be extended to many isotope therapy situations will be discussed by Mr. Marinelli, in the fourth paper of the present symposium.[5]

[4] Recently reduced from 1 rad = 20 rem.

[5] See page 656.

OTHER INSTRUMENTATION METHODS

A conventional approach for the physicist is to measure the *number* of radioactive particles or of photons passing through unit cross section, or the number of particles emitted through a given solid angle. Typical instrumentation in this category is:

Radiation	Instrument Type
Beta rays	Geiger counters (thin wall)
Photons	Geiger counters (thick wall), ion chambers
Alpha rays, protons	Proportional counters
Fast neutrons	Proportional counters with hydrogenous materials
"Slow" neutrons	Proportional counters with boron in gas or wall

In addition, scintillation counters can be arranged to serve all these functions.

Data obtained in this manner, corrected for the counting efficiency of the receptor, lead to statements of flux in various forms such as vector flux or integrated flux.

When the particle flux is supplemented by a knowledge of the energy of the particles, one derives energy flux or intensity.

Intensity of radiation is the energy flowing through unit area perpendicular to the beam per unit time. It is expressed in ergs per square centimeter per second, or in watts per square centimeter.

Quantity of radiation is the time integral of intensity. It is important to realize that this physical meaning of quantity of radiation is not necessarily that which is implied in the definition of the roentgen, nor is it a concept of particular value in radiology.

Absorbed dose-rate can be derived from intensity (or absorbed dose from quantity) if the appropriate absorption coefficients in the medium of interest are known.

This would be the normal physical approach to the dose problem. Inherently, it is predicated on idealized situations with indefinitely narrow pencils of radiation. Many practical treatment situations involve relatively wide beams or a multiplicity of beams. The absorbed dose may then be largely affected by scattered radiation in a large tissue mass. Dr. Laughlin's paper[6] will be concerned with the topic of intensity versus dose.

The integration of dose at a point, when the approach is made by the intensity method, is a complex exercise for the physicist. The superiority of the Bragg-Gray Principle is essentially that the method automatically performs such an integration and arrives more directly at the quantity of interest in radiology. However, enthusiasm for the Principle has to be tempered by the admission that, in actual dosimetry practice, its direct use is virtually confined to operations in specialized laboratories.

The methods of this section can be formally tabulated as in Table IV.

TABLE IV: EXAMPLES OF SECONDARY METHODS
(Referable to rads through physical constants)

Receptor	Measurement Method	Function
Scintillator (tissue-equiv.)	Count $N(E)$ by pulse size discrimination	Dose is of form $\int N(E)\left(\frac{dE}{dx}\right)_E dE$
Proportional counter	Similar	Similar

Where $N(E)$ is the time integrated flux of particles of energy E, and $\left(\frac{dE}{dx}\right)_E$ is the rate of energy transfer of a particle of energy E.

In presenting these examples as secondary methods, one is showing some bias toward Bragg-Gray methods. Both systems derive absorbed dose from a physical measurement of another quantity supplemented by known physical quantities, $\left(\frac{dE}{dx}\right)_E$ in one case, and W and ρ in the other.

NON-BASIC SECONDARY METHODS

Any radiation detection instrument, which is calibrated against a primary instrument for a specific type of radiation, a specific energy range within that type, and sometimes for prescribed geometrical

[6] See page 646.

circumstances of exposure, constitutes a satisfactory measuring device. The list of instruments ranges from ion chambers and Geiger counters to film, chemical dosimeters, and calorimetric devices.

This presentation has relegated these instruments to the last position under the unflattering title of non-basic secondary methods. In their defense it can be pointed out that clearly more than 99 per cent of radiation measurements are satisfactorily made in this category. They are the workhorse tools of dosimetry, and the only hazard in their use is a failure to restrict them to the specific conditions under which their calibration against a primary standard is valid.

SUMMARY

A brief review of early dosimetry methods is given, leading to the establishment of the roentgen. The absorbed dose concept arising from the Bragg-Gray Principle is coupled with the increased interest in radiobiology to lead to direct tissue dose determination in terms of energy absorption as the method of choice.

Instrumentation methods are then classified as (1) basic primary methods if they yield absorbed dose, (2) basic secondary methods if they yield dose in roentgens, and (3) non-basic secondary methods if they require calibration against a primary method.

Some notes on appropriate methods and units for particulate radiations and for mixed exposures are given. Special cases in which energy absorption can be derived from first principles in isotope irradiation are mentioned. The alternative approach by the physical method of conversion of intensity to dose rate is indicated. Throughout, the points that will be amplified in the other contributions to this symposium are indicated.

ACKNOWLEDGMENT: This paper was prepared specifically as an orientation for the symposium. It contains little or nothing that is new. References to the contributions of various leading exponents of dosimetry will be so familiar that a bibliography would be redundant. The author uses this alternative form of acknowledgment.

Hanford Atomic Products Operation
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Richland, Wash.

SUMARIO

Unidades de Irradiación e Instrumentos de Irradiación

Ofrécese una reseña breve de los antiguos métodos de dosimetría, que condujeron al establecimiento del roentgen. Se enlaza el concepto de la dosis absorbida, partiendo del principio de Bragg-Gray, con el mayor interés despertado por la radiobiología, para conducir a la determinación directa de la dosis tejido en términos de absorción de energía como método de elección.

Clasifícanse los métodos de instrumentación en: (1) métodos primarios básicos, si dan la dosis absorbida; (2) métodos secundarios básicos, si dan la dosis en roentgens; y (3) métodos secundarios no básicos, si requieren calibración comparada con un método primario.

Preséntanse algunas notas relativas a métodos y unidades que son apropiados para radiaciones en partículas y para exposiciones mixtas. Menciónanse casos especiales en que puede derivarse la absorción de energía de los primeros principios en la irradiación con isotopos. Considérase una vía alternativa por el método físico de conversión de la intensidad en grado de dosis.

Symposium on Radiation Units

Surface Dose[1]

ELIZABETH F. FOCHT

TO THE RATHER complicated subject of the measurement of tissue doses of ionizing radiations, the surface dose adds its own problems. This present summary will touch upon the theory of dose determinations, give the methods and results of some measurements, and indicate a few of their practical applications. Calculations will be made of the energy absorbed for beams of x-radiation produced at a number of different kilovoltages and for elements of higher atomic number in the skin. The specific ionization will also be estimated for the 100 kilovolt to 1 million volt range, to see if these factors show any correlation with threshold erythema dose.

There are important difficulties in obtaining a measure of some physical quantity which will give an indication of the biological effect to be expected when the superficial tissues of the body are receiving radiation. If x-rays or gamma rays are to be measured in roentgens at a given point, then the associated corpuscular emission produced by the radiation at that point should be made to expend all its energy in the production of ionization in a known air volume. The secondary electrons set in motion by the original radiation travel distances in air which are much longer than the dimensions of the usual ionization chamber. Therefore, most of those electrons produced in the chamber volume have left it before using up all their energy in the formation of ion pairs. If, however, enough air or material of similar atomic number surrounds the measuring air volume, and if the flux of primary radiation is constant, then as many electrons will be produced to enter that volume as are leaving it. If the surrounding substance is thicker than the minimum necessary, there will not be an over-supply of electrons, as those coming from a thickness of material greater then their range will be absorbed within that material.

In treating patients at high energies, where the secondary particles travel greater distances, this electronic equilibrium becomes impossible of exact achievement. Some secondary electrons produced by the 22-mev betatron, for instance, will travel a distance in tissue of the order of centimeters.

When such a thickness of material is in front of the air cavity, there will be a change in flux of primary radiation due to the inverse-square law and to absorption within the material itself. Thus the best that can usually be done is to employ an "equilibrium wall thickness," which will produce the maximum ionization (1). This should also be air wall, that is, it should have the same effective atomic number as air at the wave length of the radiation being used.

If a sufficiently thick air wall chamber is being used, the question next arises as to the exact position at which the measurement is valid. At high energies most of the electrons causing ionization in the air volume have been produced some distance in front of it. According to Mayneord (12) the place of measurement is not the center of the effective air volume, but the center of gravity, or centroid of the build-up curve. This is closer to the source of radiation than the measuring volume of the chamber.

An interesting consideration here is that the density of the material surrounding the measuring air space will not affect the reading so long as the effective atomic number is constant and the primary radiation flux

[1] From the Department of Physics, Memorial Center for Cancer and Allied Diseases, New York, N. Y. Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13–18, 1953.

uniform. This has been indicated by Failla (13) and examined recently by Fano (14).

Suppose, however, that high-energy electromagnetic flux is decreasing, and the air space is surrounded by the equilibrium thickness of a medium of a certain atomic

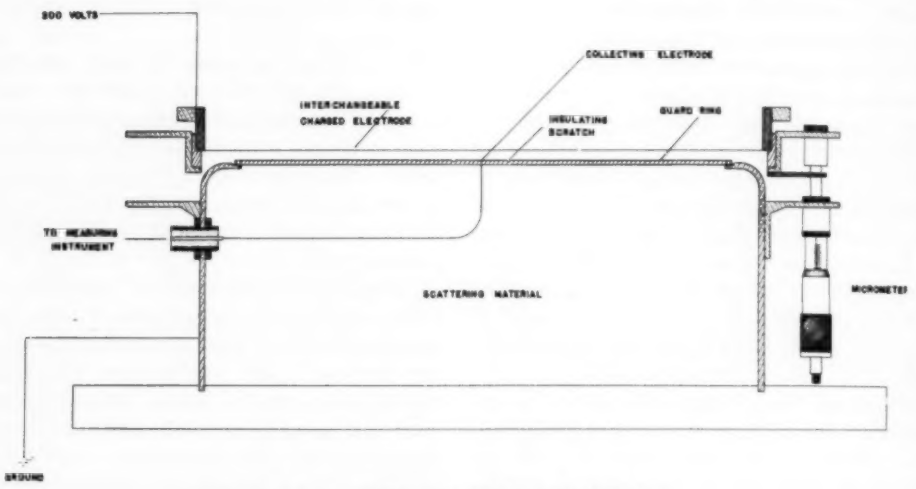

Fig. 1. An extrapolation ionization chamber. The upper electrode can be moved closer to obtain the ionization as a function of volume. Upper electrodes of varying thickness are used to obtain the ionization as a function of depth below the surface.

number and density. The reading will then refer to some point in front of the air cavity. If the material is changed to one of lower density, without change in the position of the ionization chamber, the effective position of the reading will be closer to the source of radiation.

It would be necessary then to place the centroid (or its equivalent) at the point at which the measurement is desired, and the air cavity at the position of maximum ionization. Corrections would still have to be made for wall absorption, scattered quanta from the wall material, loss of energy of electrons by radiation, etc., before a measurement equivalent to roentgens could be made. This would still not be the energy absorbed. Because of such difficulties, it has been recommended (1) that at x-ray energies above about 2 mev, the roentgen should not be used "either as a unit of x-radiation quantity or of dose."

In general, it is desirable to know the energy absorbed by the tissue at some point or throughout the volume of interest. This is not the energy flux, that is to say the intensity of the original beam, nor is it its ionization in air as measured in roentgens, but it is the energy given up by that beam to the tissues through which it passes.

At high energies the surface layers of the body are usually in a region in which the ionization is below the maximum which will be produced at greater depths. Even if the x-ray dose could be measured in roentgens at a slight depth below the skin surface, this would not give the actual ionization nor the energy absorbed at that layer as it is under actual treatment conditions, that is, without the equilibrium thickness on it.

The energy actually dissipated in the body cannot be readily measured directly. Instead, a small air volume is inserted into a phantom material and the ions formed in it are measured. This is the cavity postulated by the Bragg-Gray relation, or, in practical work, the ionization chamber. When the correct conditions of wall ma-

terial, size of cavity, etc., are met, the ionization per unit volume in the air cavity in the material can be converted to the energy absorbed. Here the wall of the air cavity should be the same as the material (tissue, bone, cartilage, fat, etc.) in which it is desired to know the energy absorption.

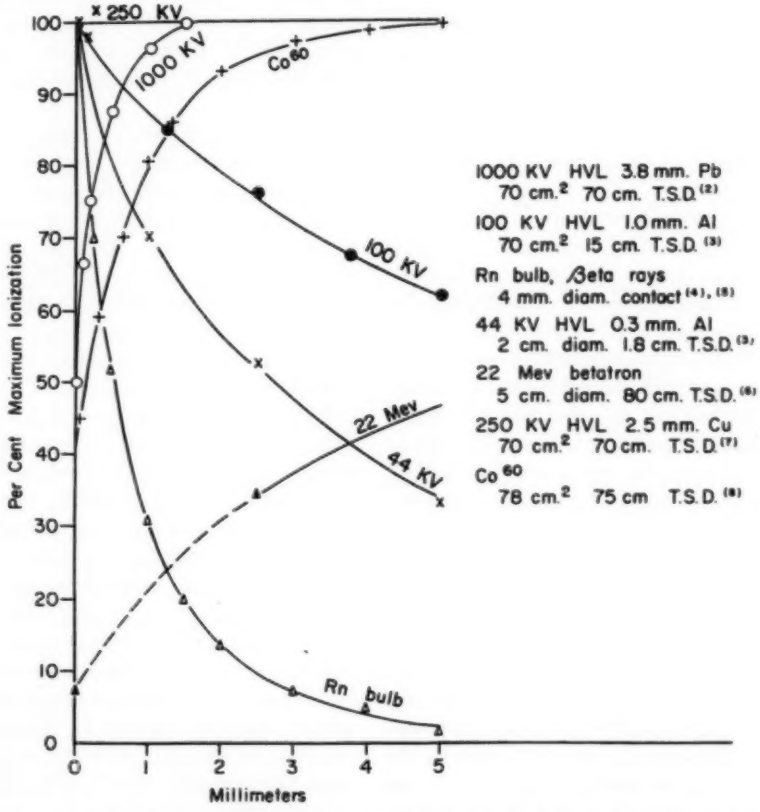
x 250 KV
1000 KV
Co60
100 KV
22 Mev
44 KV
Rn bulb
Per Cent Maximum Ionization
Millimeters
1000 KV HVL 3.8 mm. Pb
70 cm.2 70 cm. T.S.D. (2)
100 KV HVL 1.0 mm. Al
70 cm.2 15 cm. T.S.D. (3)
Rn bulb, Beta rays
4 mm. diam. contact (4), (5)
44 KV HVL 0.3 mm. Al
2 cm. diam. 1.8 cm. T.S.D. (3)
22 Mev betatron
5 cm. diam. 80 cm. T.S.D. (6)
250 KV HVL 2.5 mm. Cu
70 cm.2 70 cm. T.S.D. (7)
Co 60
78 cm.2 75 cm T.S.D. (8)

Fig. 2. Ioniaztion in small air-filled chambers in first half centimeter of unit density phantom material. Maximum ionization taken as 100 per cent.

In the region of the epidermis and dermis, say the first few millimeters, the ionization for low voltages or short distances may decrease very rapidly with increasing depth because absorption and the inverse-square law are important. For very high voltages it may increase steeply, as for the 22-mev beam, where there is build-up because the equilibrium thickness is not reached until more than 3 cm. below the surface.

The measurement of such depth doses near the surface is difficult, as the usual ionization chamber is much larger than the skin thickness in which one is interested, and the ionization is changing so rapidly that it may be quite different at the front and the back of the chamber. To obtain the reading at the very top of the skin surface there should be no upper wall to the chamber. To pin-point the reading at this upper position, the air volume would have to be vanishingly thin. These objectives are met by the extrapolation ionization chamber (15) (Fig. 1). Using chambers of this type, some of the curves shown in Figure 2 were obtained in terms of ionization per cubic centimeter.

The data for the radon bulb curves were taken with the same small extrapolation chamber used some years ago by Quimby

and Focht (3) and agree well with data recently published by others (5). A few points near the surface at 250 kv. were taken using the extrapolation chamber shown in Figure 1. The thinnest upper electrode was about 40μ of polyethylene. These points are not more accurate than a few per cent and so are shown scattered.

The betatron curve was taken with a small nylon chamber of about 2 mm. depth, and the cobalt with a polystyrene disk-shaped chamber of about 1.5 mm. spacing. The 100-kv. points, taken with an ordinary thimble chamber, are shown for comparison.

A further consideration is that the curves of Figure 2 taken at Memorial Hospital are averages of the ionization obtained with plus and minus polarity on the chamber, wherever the two differed. For the radon bulb, of course, the reading with negative saturation potential on the upper electrode is greater, due to the additional effect of beta rays from the bulb. Their effect can be seen to cancel out by taking the average of the plus and minus collections.

As they stand, these curves do not give the absorbed energy, but can be shown to be proportional to it for practical purposes. The energy can be obtained from the same data by using the Bragg-Gray formula $E_v = J_v W \rho$, where E_v is the energy absorbed per unit volume of the material, J_v is the ionization per unit volume in the small air cavity in this material, W is the average energy expended to produce an ion pair, and ρ is the ratio of the energy lost per unit path of the tissue to the energy lost per unit path of the air. Thus one can calculate the energy absorbed in that amount of tissue, had it been there instead of the air volume.

The ionization is measured and, where W and ρ are constant for a given beam, this can be multiplied by $W \times \rho$ to obtain the ergs per unit volume of tissue. This is per gram in unit density tissue. The new curve of ergs per gram would then have the same shape as the ionization per cubic centimeter curve, as the latter has merely been multiplied through by a constant factor.

If the chamber walls were not exactly tissue-equivalent in any of the curves of Figure 2, it might be argued that corrections should be made to get the accurate energy absorption. But then the exact composition of the tissue itself may not be too well known and, as will be shown, if elements of higher atomic number are present, the corrections would be even larger.

One could then go from any of the previous curves to the absorbed energy by using the same conversion constants and, after getting the ergs per gram, put it in terms of rads, where the new unit, the rad, equals 100 ergs per gram. Because of the difficulty in measuring the dose according to the definition of the roentgen at very short wave lengths, an energy unit such as the rad should be used.

In the lower voltage region, the ionization per cubic centimeter measured at a depth below the surface with an air wall chamber has been stated as roentgens. If the energy of the radiation is known, then a calculation can be made on the basis of the ratio of the absorption coefficients of the material to air in order to obtain the energy absorbed. These ergs per gram per roentgen for muscle, for instance, are quite constant over a wide range of initial x-ray photon energies. Such measurements can then also be given in terms of rads by using the factor 100 ergs per gram equals 1 rad.

Plots of rads against depth in tissue would not be the same as the usual depth dose curves in an air wall chamber in presdwood or water if the atomic number of the part of the body irradiated were different. For instance, 85 ergs are absorbed by a gram of air for 1 roentgen, but at a h.v.l. of 1 mm. Cu a gram of bone would absorb over 200 ergs for this same roentgen. In any anatomical location, if there are higher atomic number elements present, the specification of the energy absorbed—in rads for instance—would be a more direct indication of the result to be expected.

In particular, let us consider the use of a few of the plots of Figure 1 in an analysis of the threshold erythema effect and point out a few factors which may have to be taken into consideration in correlating this biological effect with dose. The following is intended only to indicate methods of approach to such a problem and is not expected to formulate any final conclusions.

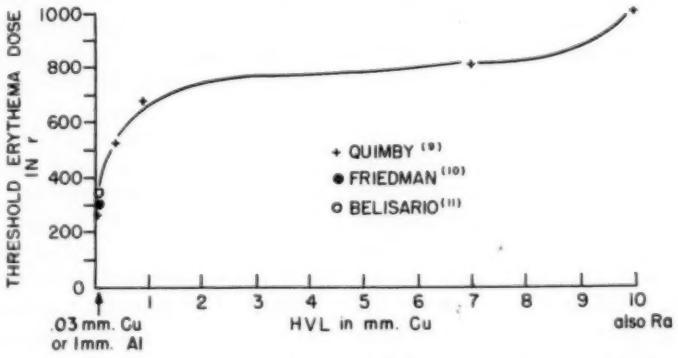

Fig. 3. Roentgens at skin to produce threshold erythema dose as a function of half-value layer.

It is well known that the roentgens which are necessary to produce the skin threshold erythema are greater with high kilovoltages. The T.E.D. is that single skin dose which will produce in 80 per cent of those tested a faint but definite erythema and in the other 20 per cent no visible reaction. Figure 3 shows the results of some tests. These are in terms of roentgens on the skin, measured with back-scatter and given in a single dose. Quimby's studies were made on the inner surface of the forearm, on about a 70-sq. cm. area. Friedman used a 3 × 3-cm. field on the anterior thigh. Belisario's results were also obtained on the thigh, with a 1-cm. diameter field. He specified roentgens in air, but the back-scatter is only a few per cent for h.v.l. of 1 mm. Al and a 1-cm. field. There seems to be very good agreement among these observers for this low quality, especially when it is considered that their definitions of threshold erythema are not exactly the same, that the smaller field probably requires a higher dose for the given biological effect, and also that it is a steep part of the curve.

Whatever the units of the surface dose plots, another problem in the specification of dose is the determination of the depth at which the cells of interest lie. If the curves were practically flat for the first several millimeters, as shown by the 250-kv. line in Figure 1, the dose would be the same whether it was decided that the cells to be considered were at a depth of a fraction of a millimeter or more. However, for those qualities of radiation which show steep slopes, cells at a depth of a few millimeters may receive a dose quite different from the maximum or from that at the very skin surface. If the location of the cells which are important in the production of the threshold erythema is not known accurately, it may be necessary to take an average value, or to integrate over some depth interval to obtain the total energy absorbed in ergs or in gram-rads, where 1 gram rad = 100 ergs.

Failla (16) in a 1937 paper on the decrease in the skin ionization in "supervoltage" therapy, summarizes the data of several authors, and states that the erythema reaction occurs in the case of gamma rays within, at most, 2.5 mm. of the skin surface and probably within 1 mm.

Some of the tests were done on the inner aspect of the forearm. The epidermis of skin from the forearm is about 0.05 mm., perhaps 6 cells thick, and the dermis may be about

twenty times that, or about 1 mm. (17).

Some data from the one-million-volt tests (2) would also make it seem probable that the first 1.5 mm. are important with respect to this reaction. The first tests were done with no covering on the skin and, when the dose was 1,000 r measured at the maximum rise of the curve, gave no particular reaction. The skin covering used after that increased the dose in the first 1.5 mm. only, by bringing it up to the maximum, and yet the T.E.D. was obtained at this same 1,000 r.

Under normal treatment conditions, there is enough air between the tube and the skin so that the 100-kv. and 250-kv. beams are at or very near electronic equilibrium in air. No build-up was found with the 250-kv. beam in Figure 2. If these beams are at equilibrium in air, they will still be in equilibrium in the skin if it is of similar atomic number but greater in density only. The decrease of the 100-kv. beam is due to absorption. In the case of the the 1-mv. tests to be described, there was 1.5 mm. of tissue-equivalent material covering the skin, so that all these three qualities were in electronic equilibrium. Yet the dose of radiation measured in roentgens required to produce a given biological effect varies by a factor of more than 3 from a h.v.l. of 1 mm. Al to 10 mm. Cu.

Since it is not known just where the cells active in producing the erythema lie, suppose the dose for threshold erythema reaction were integrated over as much as the first few millimeters of the 100-kv., 250-kv., and 1-mv. beams. It would be the same for 250 kv. and 1 mv., as both curves would be flat over the first few millimeters under the same conditions. For the same field size, this product of grams of tissue times roentgens in the tissue would, for the 100-kv. beam, be about 89 per cent of the others, since the curve in Figure 2 is decreasing. This would indicate an even lower dose for the threshold erythema at low half-value layer.

Some other factors must therefore be considered for an explanation of the varying number of roentgens for the same skin reactions. Various authors have suggested the possibility of greater absorption at lower energies by materials of higher atomic number, mainly sulfur, in the skin. At lower energies, the ergs per gram would be greater than if the tissue were considered to have an effective atomic number about the same as water.

Most of the sulfur in the skin is probably in the form of cystine and methionine. Block (18) states that the epidermal layer of human skin contains 3.8 gm. cystine and 0.8 gm. methionine per 100 gm. protein. The sulfur amino acids were present in much lower concentrations in the thick corium layer, which contained approximately 0.1 gm. of cystine and 0.8 gm. of methionine per 100 gm. of protein.

Mayneord (19), for the lower energy region where the photoelectric absorption is important, has calculated the effective atomic number of cystine as 10.76 and of methionine as 10.03. Various texts give traces of Na, K, Ca, Mg, Cl and P which total less than 1 per cent of dry weight of the skin. The amount of water in the skin (dermis and epidermis) is quoted at 60 to 70 per cent.

Suppose as high a value as 2 per cent total of the above elements—plus compounds—in wet epidermal skin is assumed, with about 11 for the effective atomic number. If the absorption were completely due to the photoelectric process, then the ratio of the energy absorbed by tissue containing the above substances uniformly distributed, to the usual tissue of atomic number about 7.4 would be

$$\frac{(.02)(11)^3 + (.98)(7.4)^3}{(7.4)^3} = 1.05$$

If such a calculation were applied to the 100-kv. beam, the figure would be even smaller, as some of the absorption is due to Compton electrons.

In the region where the Compton scattering is predominant, the energy absorption is independent of atomic number and the value per gram depends only on the number of electrons per gram. Any correction for the 250-kv. and 1-mv. beams

according to the above assumptions would therefore be even less.

In order to show any large differences in the dose for these qualities of radiation, it would have to be assumed that the compounds containing the greater atomic number elements were highly concentrated. It would also have to be assumed that the sensitive volume whose irradiation produced the reaction was very close, within the range of the electrons from the sulfur (19).

Another factor which should perhaps be considered is that of specific ionization, which may be defined as the number of ion pairs per unit length of path of the ionizing particles. Although macroscopically, over the few millimeters of the ionization chamber, we may read the same number of ions, yet microscopically, over the dimensions of the cell, the spacing of these ions may cause a difference biologically. This has been mentioned by various authors and considered more closely by some investigators in radiobiology.

L. H. Gray (20), using data compiled by Lea (21), plotted the ionization per μ in tissue as a function of tube kilovoltage. We have redone this very roughly for our own conditions, including a weighting of the back-scatter. Cormack and Johns (22) have published a rigorous analysis of the electron energies and ion densities in water. Their qualities ranged from a beam of 200 kv., h.v.l. 1 mm. Cu, to that of a 25-mev betatron. For this discussion, we are not interested in absolute numbers, but in the ratios, which are close enough for our present purposes. For an approximate calculation then, Greening's (23) method analyzes the spectral distribution of an x-ray beam by means of its absorption curve. In this manner Spiers (24), using the Memorial Hospital half-value layer, obtained the mean photon energy of the million-volt machine as 460 kev. Johns has published similar curves for some 200–400-kv. beams. The mean energies for the 100-kv., 250-kv., and 1,000-kv. radiations were taken approximately as 45 kev, 130 kev, and 460 kev. Lea gives the mean electron energy,

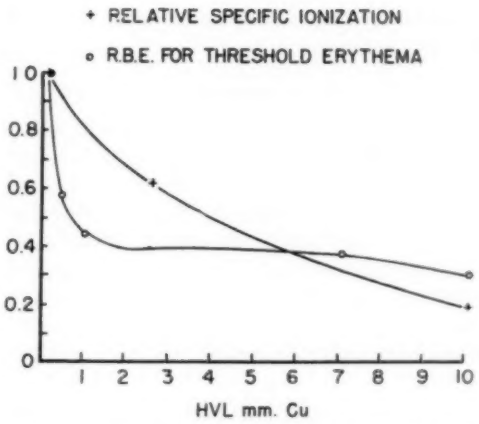

Fig. 4. Experimental points for the relative biological effect for threshold erythema, with the value for the lowest quality x-ray beam taken as 1. Approximate calculated points for relative specific ionization.

weighted for the proportions of photon and Compton electrons, which would be produced in water by x-radiation of different kilovolts.

He also gives the ranges for such electrons. The specific ionization can thus be obtained approximately by dividing the mean electron energy by W, the average energy dissipated in the formation of an ion pair, thus getting the total number of ion pairs, and dividing this by the range in μ to get the ion pairs per μ.

This was done for the mean photon energies given above and also weighted for about 12 per cent of the total skin dose due to back-scatter at 100 kv., 20 per cent at 250 kv., and 9 per cent at 1 mv. The different quality of this back-scattered radiation was allowed for, and would have erred on the side of showing the specific ionization less different as the quality changes from 100 kv. to 1,000 kv. Yet calculation showed an overall factor of about $\times$ 5 through this range.

If the term relative biological effectiveness is used and the T.E.D. at 100 kv. is put equal to 1, then RBE of the mv. can be taken as the ratio of the surface roentgens at the two qualities to produce the same biological effect, in this case threshold erythema. This is 300/1,000 or 0.3. In Figure 4 the RBE is plotted against

relative specific ionization, with that of 100 kv. taken as 1.

SUMMARY

1. Reasons for using a unit of absorbed energy for specification of surface dose above about 2 mev have been discussed. This rests on the difficulty of measuring the roentgen at high energies. Moreover, roentgens would have no simple relation, especially in the build-up region, to the entity which is more directly related to the biological effect, namely, the energy absorbed.

2. To be of biological relevance, the surface dose should be specified not at some vanishingly thin upper surface of the inactive layer of the epidermis, but through the region in which the cells of interest lie. If the surface dose curves are very steep, this may be done by taking the integral dose over the critical depth interval.

3. Account should be taken of the effect on the amount of energy absorbed due to elements of different atomic number. The ionization reading should be made with a cavity wall of the same atomic number as the tissue in question, or, where roentgens can be measured, a calculation can be made on the basis of the relative absorption coefficients if the spectrum of the radiation is known.

4. The above factors should still not be regarded as a unique description of the radiation given. The time factor, for instance, is known to be important, and other variables such as the specific ionization should perhaps also be considered.

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SUMARIO

Dosis Superficial

Discútense las razones que hacen usar una unidad de energía absorbida al estipular dosis superficiales superiores a unos 2 mev. Esto se asienta en lo difícil que es medir el roentgen a energías elevadas. Además, los roentgens no guardarían una relación sencilla, sobre todo en la región de aglomeración, con la entidad que está enlazada más directamente con el efecto biológico, a saber, la energía absorbida.

Para que posea pertinencia biológica, hay que especificar la dosis superficial, no en una superficie superior de delgadez borrosa en la capa inactiva de la epidermis, sino a través de la región en que quedan las células que interesan. Si son muy empinadas las curvas de la dosis superficial, puede hacerse eso tomando la dosis integral durante el intervalo profundo crítico.

Hay que tomar en cuenta el efecto ejercido sobre la cantidad de energía absorbida por elementos de distinto número atómico. La lectura de la yonización debe hacerse con una pared de cavidad del mismo número atómico que el tejido dado, o, si pueden medirse los roentgens, cabe hacer un cálculo a base de los coeficientes relativos de absorción, si se conoce el espectro de la irradiación.

Tampoco hay que considerar los factores anteriores como descripción única de la radiación administrada. Por ejemplo, ya se sabe que el factor tiempo es importante, y quizás haya además que considerar otros factores variables, tales como la yonización específica.

Symposium on Radiation Units

Intensity and Absorbed Dose Rate[1]

JOHN S. LAUGHLIN, Ph.D.

FOR THE RADIOLOGIST and for the investigator using radiation beams, the two most important and commonly used concepts in the quantitative measurement of radiation are the output of the source of radiation and the absorbed dose produced in tissue by the absorption of the radiation. In more absolute and precise terminology, output refers to the intensity of a radiation beam, while absorbed dose refers to the energy absorbed in a unit mass of the absorbing material. These are distinct quantities, the following definitions being taken from the recommendations of the International Commission on Radiological Units (1953) (1).

"*Intensity of radiation* is the energy flowing through unit area perpendicular to the beam per unit time. It is expressed in ergs per square centimeter per second or watts per square centimeter."

"*Quantity of radiation* is the time integral of intensity. It is the total energy which has passed through unit area perpendicular to the beam and is expressed in ergs per square centimeter or watt-seconds per square centimeter."

"*Absorbed dose* of any ionizing radiation is the amount of energy imparted to matter by ionizing particles per unit mass of irradiated material at the place of interest. It shall be expressed in *rads*."

It should be noted that no definition of dose was agreed on, so that the term "absorbed dose" is the only one having a precise meaning. In this discussion we shall employ the defined term, "absorbed dose," and shall mean this even when the expression "dose" is used. "The *rad* is the unit of absorbed dose and is 100 ergs per gram." The erg is 0.63×10^{12} electron volts and is equal to the amount of energy required on the average by an electron to ionize approximately 20 billion atoms of air. The use of absolute units achieves the ideal of definite and unambiguous terms of measurement. However, the recommended use of absolute units raises practical questions:

How can the output and absorbed dose be expressed in absolute units? What is the relationship of our conventional ionization measurements to absolute intensity and absorbed dose rate?

Consideration of these questions will aid the exposition of the significance of and distinction between absorbed dose rate and intensity.

Historically, various methods have been used for the detection of radiation. These include action on fluorescent materials, photographic film, and color pastilles, resistance of irradiated selenium, and the production of ionization in gases such as air. Of these methods, ionization measurements have been primarily employed for indirect quantitative determinations of both intensity and absorbed dose rate. When x-rays are absorbed in any medium, energy is imparted to secondary electrons. These electrons lose their energy through ionization and excitation of the atoms of the absorbing medium. Unless chemical change results, all this energy is eventually converted into heat energy. The average energy lost by an electron per ion pair formed has been determined accurately for various substances and for a medium such as air is fairly constant over a wide range of energies of the electron (10). Consequently, a measurement of ionization can be related to energy per unit mass of the absorbing body absorbed from the beam, which is the absorbed dose, and also to the energy flux density, which is the intensity of the incident beam. Moreover, ionization measurements in air are reproducible and the technics are well de-

[1] From the Department of Physics, Sloan-Kettering Institute and Memorial Hospital, Memorial Center, New York, N. Y. Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13–18, 1953.

veloped. Therefore, from the standpoint of convenience and easily reproducible determinations, the use of ionization measurements has been quite successful.

The use of the roentgen,[2] which involves the measurement of ionization density in air, has been successful because of these advantages of the ionization measurement method. The most precise measurement of the roentgen requires a large air-ionization chamber in which the irradiated volume is accurately known. Since it is not convenient to transport or construct these large chambers for every x-ray source to be calibrated, a small type of thimble ionization chamber was developed. The proper use of these small chambers in place of a large air-ionization chamber rests on theoretical arguments developed largely by Bragg (2) and Gray (3). Their theoretical developments, together with the accomplishments of Glasser (4), Failla (5, 6), and others, permitted the condensation of the air of the standard ionization chamber into a solid wall surrounding an air cavity. The composition of this wall had to be equivalent to air in its absorption properties and, for the roentgen, its thickness had to be such as to secure equilibrium in the production of the secondary electrons. This successful development permitted the widespread use of small thimble ionization chambers and made practicable and convenient the calibration of the radiation from x-ray machines, regardless of location.

A consequence of the widespread use of simple thimble chamber measurements has been the growth of the custom of expressing both the output of machines and the absorbed dose in air or tissue in terms of this single quantity—the roentgen. The roentgen is not a direct measure of either intensity or absorbed dose. The technical ease with which it can be measured by a simple chamber and the custom of expressing both output and absorbed dose in terms of the reading of this simple device has sometimes led to a lack of distinction of the entirely separate quantities: intensity and absorbed dose rate.

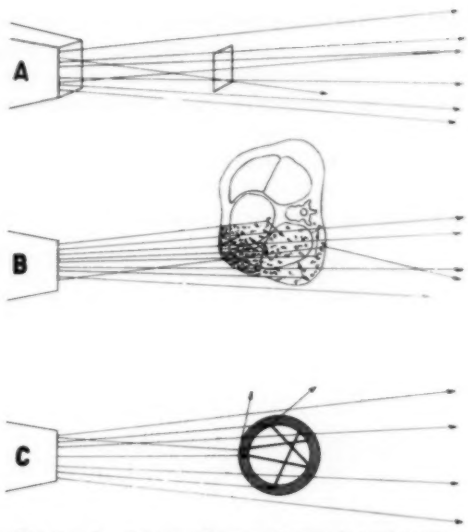

Fig. 1. A. A beam of x-ray photons is depicted issuing through a cone. The intensity at the point indicated by the square area normal to the beam is the energy in ergs passing through each square centimeter per second.

B. A section of a body is shown exposed to a radiation beam. Some of the photons are absorbed or scattered while others are transmitted. The short irregular lines represent secondary electrons which dissipate their energy through ionization and excitation. The density of the tracks decreases with increasing depth in the body as the intensity of the beam is attenuated.

C. An air ionization chamber is represented in an x-ray beam. Some of the photons produce secondary electrons in the chamber walls, which pass through the chamber gas and produce ionization.

Figure 1 illustrates the concepts of both intensity and absorbed dose. In A, a beam of radiation is shown issuing from a target through a cone. This beam consists of photons traveling at the speed of light. The intensity of this radiation beam at any point in it is the energy flowing per unit time through a unit area normal to the beam. Its intensity at a given point in absolute units is the number of ergs passing through an area of 1 sq. cm. normal to the direction of the beam per second. To measure this energy flux density directly is difficult.

In B of Figure 1, the same beam of radia-

[2] The International Commission on Radiological Units (1953) confirmed the previous definition of the roentgen: "The *roentgen* shall be the quantity of x- or γ-radiation such that the associated corpuscular emission per 0.001293 gram of air produces, in air, ions carrying 1 electrostatic unit of quantity of electricity of either sign."

tion is shown incident on a section of the human body. Some of the photons pass completely through; others are absorbed. The short, irregular lines represent the secondary electrons which produce excitation and ionization of the atoms in tissue. Beyond the depth required for equilibrium, the number of secondary electrons That part of the energy which is dissipated in the form of ionization can be indicated by collecting the resulting ion pairs in an electrostatic field. The Bragg-Gray relation shows how this measurement of ionization in the gas can then be related to the energy absorbed in the surrounding wall material.

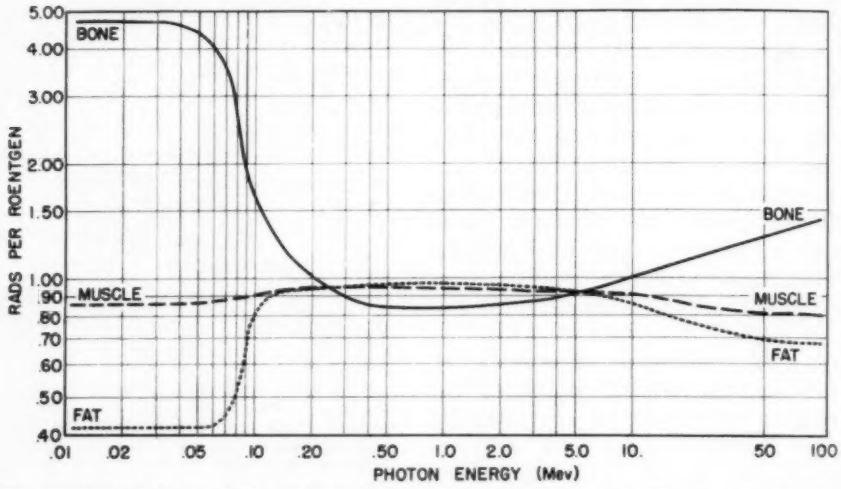

Fig. 2. Absorbed dose in indicated materials as a function of photon energy in mev. Courtesy of Nucleonics **8:** 5–16, April 1951. See also references 14 and 15.

decreases as the beam is attenuated in passing through the body. The energy absorbed per unit mass, or absorbed dose, which is proportional to the amount of ionization and excitation, therefore also decreases with increasing depth in the body. According to the definition, the absorbed dose at any point is simply the energy absorbed in ergs per gram of the medium there. A direct measurement of this is also extremely difficult.

C of Figure 1 represents an air cavity surrounded by a wall in the path of the same x-ray beam. Some of the incident x-ray photons are absorbed in the wall of this ionization chamber, and the resulting secondary electrons pass through the volume. This is a much over-simplified picture of the process, but it is apparent that, due to absorption of the photons in the wall of this chamber, secondary electrons in turn are produced which will dissipate some energy in the gas of the chamber.

Since the radiologist or investigator is primarily interested, however, in knowing the absorbed dose rate produced at a certain point in a body as shown in B, or, on some occasions, is also interested in knowing the intensity of this radiation beam as indicated in A, the problem is to relate the simple and convenient ionization measurement represented in C to the absorbed dose rate and to the intensity. After considering this relationship, we should like to pass on to some methods of measuring absorbed dose rate and intensity.

Since the theory of absorption of x-rays and electrons has been well established and the values of absorption coefficients of various materials are known, it is possible to calculate with fair precision from ionization measurements either the intensity of the incident beam or the dose rate that it will produce in given materials.

The interpretation of ionization density measurement in air cavity chambers to

give the absorbed dose in the surrounding absorbing medium rests on the principles underlying the Bragg-Gray relation. A simple form of this relation is:

$$E_v = \rho W J_v \qquad (1)$$

where E_v is the energy absorbed per unit volume of the absorbing medium, ρ is the stopping power of the secondary electrons in the medium relative to that in the gas of the chamber, W is the average energy dissipated per ion pair formed in the gas of the chamber, and J_v is the density of ionization produced in the gas of the chamber. The chamber is required to be sufficiently small so that its presence does not perturb the distribution of secondary electrons.

A precise calculation of ρ requires a knowledge of the spectrum of the secondary, tertiary, etc., electrons passing any point in the medium and in the gas, and also a knowledge of the stopping power of the medium and the gas as a function of the energies of the electron.

It can be shown that the definition of the roentgen corresponds to the absorption in 1 gram of air of about 84 ergs. This rests on the assumption that the average energy dissipated by an electron per ion pair formed is 32.5 electron volts, regardless of the energy of the ionizing electron. The energy absorption in other materials in terms of the roentgen is then given by Equation 2:

$$D_{ab} = \frac{({}_e\mu_a)_x \, N_x}{({}_e\mu_a)_a \, N_a} 84 \qquad (2)$$

where D_{ab} is the energy absorbed/gram-roentgen in material x, $({}_e\mu_a)_x$ is the true absorption part of the electronic coefficient of attenuation of x-rays in material x, $({}_e\mu_a)_a$ is the true absorption part of the electronic coefficient of attenuation of x-rays in air, N_x is the number of electrons per gram in the material x, and N_a is the number of electrons per gram in air. The results of such a calculation for different energies of x-rays are shown in Figure 2. Details of this calculation are given elsewhere (16). Using the definition, 1 rad = 100 ergs/gram, this graph gives the number of rads of absorbed dose absorbed in bone, muscle, and fat, per roentgen as a function of photon energy.

It is seen that at low photon energies, 1 roentgen of radiation produces in bone an absorbed dose of about 5 rads, whereas in fat it produces an absorbed dose of only about 0.5 rad. In soft tissue the variation of rads per roentgen remains fairly constant between 0.8 and 1.0 rads. Such a calculation and graph illustrate how a simple ionization measurement in roentgens is related to the absorbed dose, or absorbed energy per gram, in a given material.

The quantity of radiation (intensity × time) required to produce 1 roentgen is given by Equation 3:

$$E_A \mu_a = 84g \qquad (3)$$

where E_A is the quantity of radiation in ergs/cm.^{2} per roentgen, μ_a is the true absorption part of the total linear attenuation coefficient for air, and g is the density of air. This expression is an over-simplified equation, since it assumes equilibrium without attenuation and ignores the scattered component of radiation. Figure 3 is a graph of Equation 3, and indicates the quantity of radiation in the beam in ergs/cm.^{2} required to produce 1 roentgen by x-rays of various energies. To express the quantity of radiation in terms of any given radiation beam, it is necessary to integrate over the spectrum of the radiation emerging from that particular source. Assuming this is done, this calculation and graph illustrate the relationship between a simple ionization measurement expressed in roentgens and the quantity of radiation (intensity × time) of the beam.

The preceding calculations and graphs relating ionization measurements to the quantity of radiation (intensity × time) and absorbed dose apply to the particular case of x-ray beams. Similar calculations for the electron beam result in the following graphs.

Figure 4 shows the dependence on different primary electron energies of the absorbed dose in water in rads per esu

collected per cubic centimeter in an air cavity ionization chamber. The magnitude of the energy dependence is pronounced if the polarization density effect is included. Consideration of the degraded secondary and tertiary electron spectrum tends to reduce the amount of energy dependence. In Figure 4 the polarization density effect has been included together with an estimate of the influence of the associated secondary electrons. Since the absorption of electrons of a given energy is primarily dependent upon the number of electrons per gram in the absorbing material, and since the number of electrons per gram is approximately the same for most body substances, as bone, muscle, and fat, the graph for these other substances will be very similar to that of this graph for water. This is very different from the case of x-ray beams and is a result of the quite different absorption process for electrons as compared with x-rays.

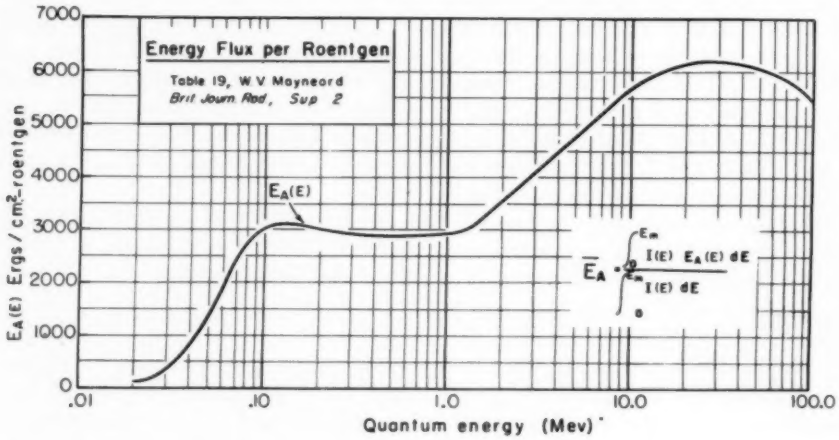

Fig. 3. Quantity of radiation (intensity × time) required to produce 1 roentgen as a function of photon energy. From calculations by W. V. Mayneord, Supp. No. 2, Brit. J. Radiol., p. 136 (13).

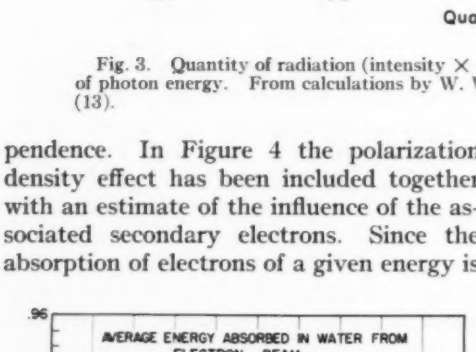

Fig. 4. Absorbed dose in water equivalence of unit ionization density in air cavity immersed in water bath exposed to an electron beam of the indicated primary energy.

Figure 6 shows a calculation of the quantity of radiation (intensity × time) of electron beams required to produce an ionization density of 1 esu/c.c. in air. The total specific ionization (9) produced in air by monoenergetic electrons has been used in this calculation. Figure 5 is a plot of the total specific ionization as a function of electron energy, obtained from a modification of an expression for probable specific ionization (7). This expression has been normalized to agree with experimental data at 20 mev (8). In order to realize experimentally the relation plotted in Figure 6, it would be necessary to employ an ionization chamber in a broad electron beam with walls sufficiently thin to produce negligible scattering of the primary electrons. In actual practice, reproducible results are obtained with a

250-r Victoreen thimble chamber with an added cap of the same wall material 4 mm. thick. With 17.5-mev primary electrons, whose intensity was measured with the aid of a Faraday cage, 760 ergs/cm.[2] were required to produce a unit reading with the Victoreen, which compares unexpectedly closely with a value of 747 ergs/cm.[2] per esu/c.c. in Figure 6.

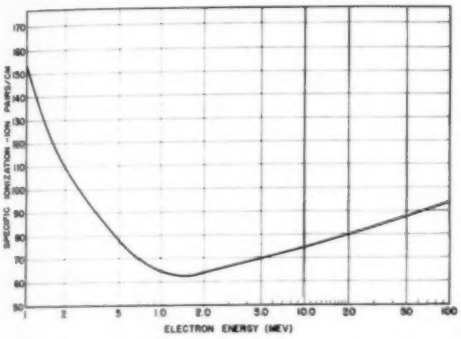

Fig. 5. Theoretical total specific ionization of electrons of indicated energy in air. Normalized to agree with experimental data at 20 mev.

Although relatively simple ionization measurements can be interpreted to give both absorbed dose rate and intensity for both x-ray and electron beams, it is obviously desirable to measure these quantities more directly. The intensity of x-ray beams of any energy can be measured directly by calorimetric methods. In a simple absorbing medium in which the absorbed x-ray energy does not result in chemical or nuclear change, all of the energy eventually is transformed into heat energy and results in an elevation of the temperature of the absorbing material. A heavy absorbing medium such as lead, tungsten, or uranium is used to totally absorb the incident x-ray beam. The temperature rise in the absorbing block is then measured by means of the resistance change of a thermistor. Measurements are in progress on various x-ray generators varying in energy from 50 kev to 25 mev under different filtration conditions.[3] Details of this technic, together with preliminary results, have been published (9).

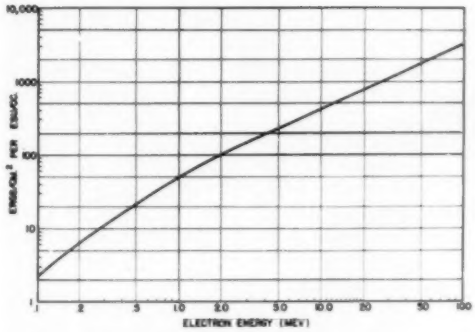

Fig. 6. Calculated quantity of radiation (intensity × time) of incident electron beam required to produce an ionization density of 1 esu/c.c. in air.

Although intensity measurements are of interest in themselves, their greatest importance is the information that their determination contributes to fundamental knowledge. Together with the accurate measurement of the ionization density in small gas cavities in various absorbing media, the determination of the intensity permits a test of the validity of the Bragg-Gray relation for different energies of radiation, and for different absorbing materials. The combination of intensity measurements with the total integrated ionization produced in a small gas chamber moved throughout the volume of the absorber permits a determination of an average value of $W\rho$ (the product of the average energy dissipated per ion pair formed and the relative stopping powers) in the cavity gas for a given energy of incident radiation. These possible results are the major reason for the interest in intensity determinations.

The absorbed dose can also be measured experimentally by the comparison of two separate experimental measurements, an alternative to the calculation procedure illustrated above. The experimental method we are employing for the measurement of absorbed dose combines the calorimetric determination of the quantity of radiation and a measurement of the distribution of the absorbed energy in the absorbing medium. This distribution can be measured with an ionization chamber in

[3] These measurements are supported in part by AEC contract At-(30-1)-1451.

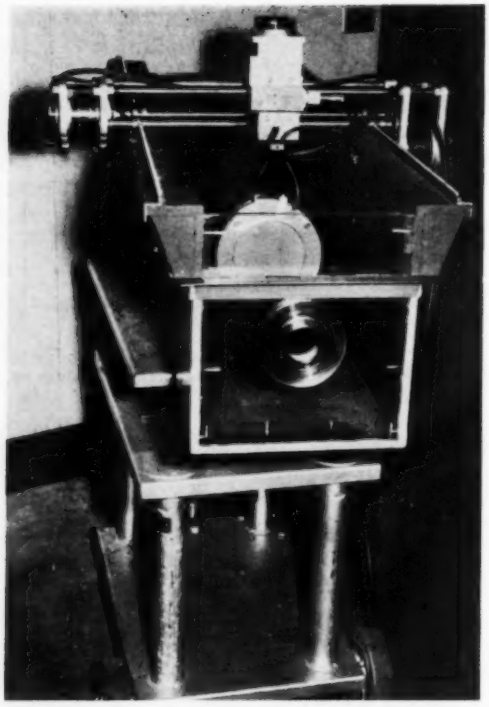

Fig. 7. Long water bath designed for absorption of a collimated high-energy x-ray beam. The flat ionization chamber shown has an inside diameter of 15 cm. and a plate spacing of 2 mm. It can be moved through the bath to integrate all ionization produced under cavity conditions in air surrounded by water.

this medium. It is important to consider any effect the change in quality of the radiation at different depths in the absorber has on the absorbed dose equivalence of ionization density. The quantities ρ and W in the Bragg-Gray relation are essentially constant (10) over the range of radiation qualities produced in a low atomic number absorber by any particular x-ray spectrum above 50 kev in peak energy. Consequently, the integrated ionization will be proportional to the total energy absorbed, within the accuracy of the ionization density measurement. Scintillation crystals (11) can also be used, though only for beams with peak energies above 0.2 mev. For radiation beams above 1 mev in peak energy, the density of photographic film is linearly related to absorbed dose, though the precision ordinarily obtainable with films does not equal that with ionization chambers. Whatever method is used, it is the relative distribution of the energy that is of interest; absolute measurement is not required. In this method the volume distribution of energy is integrated over the total volume of the irradiated absorber to give the total charge (esu) that can be produced under air cavity conditions by the absorption of the beam in water. The quotient of the incident energy (quantity of radiation $\times$ beam area), in ergs, and the total charge collected is directly the equivalence of the energy absorbed in the medium to the ionization produced in an air cavity in ergs per esu. For a unit density material such as water, this quotient is directly the absorbed dose (ergs/gram) per ionization density in an air cavity (esu/c.c.), and is equal to $\rho W/g$ if W has the units of ergs/esu. This method thus gives the absorbed dose equivalence directly in absolute units without a dependence on the knowledge of physical variables such as stopping power, energy dissipated per ion pair, other than the assumption of their constancy.

Figure 7 shows a large water bath being used for this purpose with a flat ionization chamber mounted in it. The flat ionization chamber is moved throughout the volume of the water bath and thus permits an integration of all the ionization produced. This value, together with the calorimetrically determined incident beam intensity, gives the ergs/gram in the water per esu/c.c. collected in an air cavity chamber. Preliminary measurements with this apparatus with the 22-mev peak x-ray spectrum from the betatron indicate that for this radiation the absorbed dose equivalence in water is about 1 rad per esu/c.c., or 100 ergs/gram per esu/c.c. measured in an air cavity surrounded by water.

The intensity of electron beams can be determined with the aid of a Faraday cage measurement. This method can be used only with well collimated electron beams, so that the depth of the cage can be made sufficient to prevent loss by scatter. The cage wall has to be of a thickness sufficient

to stop the electrons completely, and preferably of a low atomic number, such as aluminum, to minimize x-ray production. Bremsstrahlung would produce secondary electrons which could subtract from the current measured. The cage is mounted in an evacuated chamber and gives the beam current in amperes. Knowledge of the area of beam and of the energy spectrum of the electrons then gives the intensity in ergs per square centimeter per second, or in watts per square centimeter.

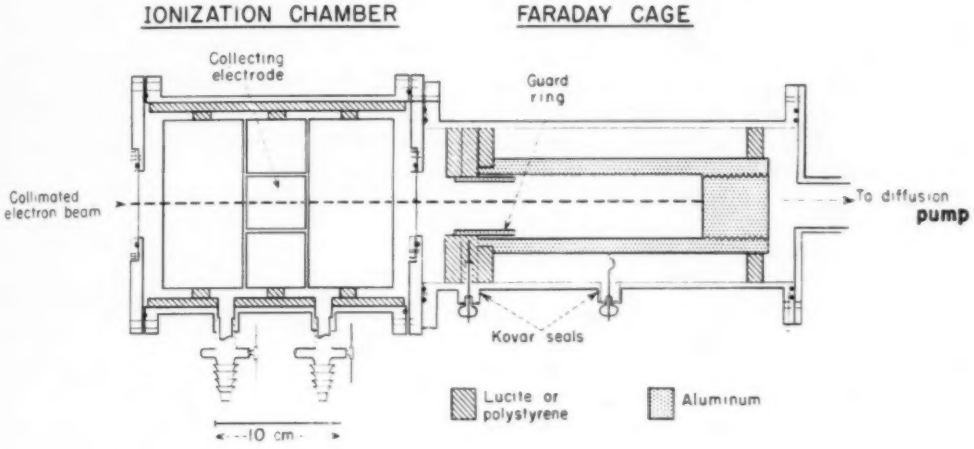

Fig. 8. Diagram of parallel plate chamber and Faraday cage.

For convenience in daily use and monitoring, transmission ionization chambers and thimble ionization chambers are calibrated in terms of the Faraday cage. Figure 8 shows an ionization chamber mounted in front of a Faraday cage so that the same beam which passes through the chamber is collected in the cage. Certain corrections are necessary because of the finite dimensions of the chamber and the long ranges of some of the scattered electrons. Figure 9 is a plot of the collision energy loss distribution as predicted by Landau (12) for 17.5-mev electrons in passing through the air of such a chamber. If the path length in a given ionization chamber were accurately known and all of the ion pairs produced by secondary electrons originating in this chamber path length were collected, a knowledge of the specific ionization and the path length would be all that would be necessary to determine the incident current. However, the energies of some of the secondary electrons produced in the gas of the ionization chamber are so high and their range is so great that not all of their ion pairs are collected. From a knowledge of the dimensions of the chamber one can determine the maximum energy of the secondary electrons whose ionization will be completely collected and

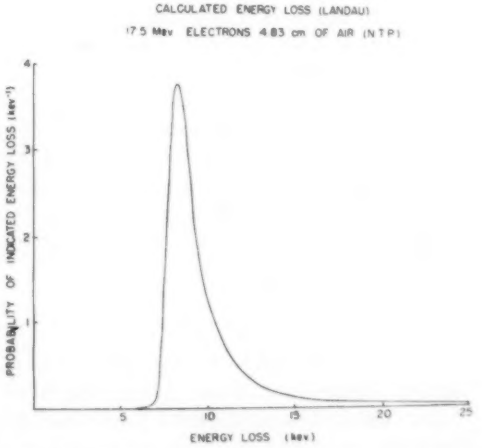

Fig. 9. Probable distribution of collision energy loss suffered by 17.5-mev electrons in passing through 4.8 cm. of air. See reference 12.

also all fractions of the ionization of the higher energy electrons which will be collected. Figure 5 has been normalized to agree with the experimental values of total specific ionization corrected for high energy scattering loss. This correction factor is in the neighborhood of 20 to 25 per cent. It is not apparent that any change in chamber design will appreciably decrease the magnitude of this correction. However, the accuracy of this correction is believed to be fairly high. Therefore, a transmission ionization chamber can be used to measure and monitor electron beam intensities if it has been either calibrated by a Faraday cage or if corrections on the basis of the probable energy loss are made and the total specific ionization is used.

The absorbed dose produced in a medium by the absorption of the electron beam can be determined by a combination of integrated energy distribution measurements and Faraday cage intensity measurements. This is the same method proposed and in process for the determination of x-ray absorbed dose. As shown in Figure 4, the absorbed dose equivalence of the ionization density in an air cavity in water is not constant for electrons of different energies, which has to be considered in the integration of the ionization density distribution.

Since the measurement of intensity and absorbed dose rate for x-ray and electron beams by some of these methods is presently under way but not completed, with respect to experimental aspects, this report can only outline the approach and some of the problems encountered. The main emphasis in this discussion of the subject has been on the fundamental concepts of absorbed dose rate and intensity, and their relationship to conventional ionization chamber measurements.

SUMMARY

1. The concepts of intensity and absorbed dose rate have been discussed. Their units of measurement have also been defined.

2. The relationship between conventional ionization chamber measurements and intensity and absorbed dose rate have been illustrated for both x-ray and electron beams.

3. The importance of intensity measurements in the study of the range of validity of the Bragg-Gray relation has been emphasized.

4. Experimental approaches to the measurement of both intensity and absorbed dose rate for both x-ray and electron beams have been briefly outlined.

NOTE: The author wishes to express his appreciation to Dr. G. Failla, Columbia University, and to Dr. J. Ovadia and Dr. J. Nickson, Memorial Center, for helpful discussions of the exposition of the significance of intensity and absorbed dose rate.

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SUMARIO

La Intensidad y la Frecuencia de la Dosis Absorbida

Cabe expresar la producción (intensidad de la radiación) de un foco de irradiación en forma de unidades absolutas como vatios/cm.^{2}. La dosis, o sea la energía absorbida, en un punto dado puede expresarse absolutamente en ergios/gramo. Los conceptos de la intensidad y la velocidad de la dosis representan distintas cantidades físicas. Puede usarse el roentgen, que está basado en una medición de la yonización, para mediciones tanto de la producción como de la velocidad de la dosis, uso este que a veces ha servido para ocultar la distinción entre dichas cantidades.

Cabe interpretar las mediciones de la yonización de modo que nos ofrezcan bien la intensidad de la radiación o la frecuencia de la dosis. Estúdiase aquí la relación general de las mediciones de la yonización y del roentgen en particular con la intensidad y la frecuencia de la dosis y preséntanse ejemplos de dichos cálculos.

Experimentalmente, puede medirse la intensidad de los haces de rayos X directamente en unidades absolutas calométricamente, mientras que puede determinarse la intensidad de los haces de electrones con mediciones en la pantalla de Faraday.

Experimentalmente, cabe valuar también la dosis (y la frecuencia de la dosis) con una combinación de las determinaciones calorimétricas de la intensidad y las distribuciones relativas de la energía. Pueden obtenerse las distribuciones relativas de la energía con un cristal de escintilación o con mediciones de la yonización. Más adelante se discutirán las suposiciones teóricas en que se asienta este método.

Symposium on Radiation Units

Radiation Dosimetry of Internally Administered Beta Ray Emitters: Status and Prospects[1]

LEONIDAS D. MARINELLI, M.A.

THE EVALUATION of the absorbed dose in biological media containing radioactive isotopes has been the object of some excellent reviews in the recent radiological literature (1–3). It is the purpose of this paper to summarize concisely the present status of the art and to speculate as to its future prospects, limiting our considerations to beta ray emitters.

We may treat the problem most simply, perhaps, by considering the dose at a given point P in a medium under three general conditions chosen according to their mathematical complexity, namely:

Case I. The point is within a homogeneous medium containing a uniform concentration, C, of radioelement extending from P to distances greater than the range, R, of the most energetic particle emitted by the isotope.

Case II. Within a spherical surface of radius R, the point in question is only partially surrounded by one or more zones of uniform concentration.

Case III. Within the same sphere, the concentration is not uniform, regardless of the spatial extent of the radioactive zone.

Case I: In this case the total dose, D_β, can be computed as (4, 5)

$$D_\beta(\text{rads}) = K_\beta C \qquad (1)$$

where

K_β = $73\,\bar{E}_\beta T_{eff}$ rads
$\bar{E}_\beta$ = the average energy per disintegration in mev
T_{eff} = actual half-life of the isotope in the tissue, or its equivalent, in days
C = concentration in μc/gram

Values for $\bar{E}_\beta$ have been published for the most popular isotopes (6) and are based on the disintegration schemes provided by the contemporary literature in physics. The half-life T_{eff} refers, of course, to the decay rate in the tissue and not to the physical constant. In those cases where the characteristics of isotope turnover cannot be described in terms of a single half-life, it is necessary to express the total number of disintegrations per gram in units of microcurie-days and calculate the dose according to Equation 1, by substituting this value for the product CT_{eff}.

Of practical importance is the accurate determination of the concentration C which, of course, involves the accurate measurement of the disintegration rate of a sample. This particular task has presented some difficulties in the past but has become manageable in the last few years. The interested reader is referred to the comprehensive report of Manov (7) issued recently by the National Research Council. It is pertinent to recall at this point that in homogeneous media, of uniform concentration and known stopping power, the dose D_β can be measured directly by cavity ionization methods, and most simply by the extrapolation chamber, irrespective of the disintegration scheme; both direct and indirect inquiries into the exactness of Equation 1 by various workers have confirmed its essential validity (8–11).

Although the case just considered is of limited value in many biological problems, it has proved useful in guiding both the

[1] From the Division of Radiological Physics and the Division of Biological and Medical Research, Argonne National Laboratory, Lemont, Ill. Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13–18, 1953.

physician to the rapid attainment of optimum radiotherapeutic dosage and the health physicist to the establishment of approximate, but nevertheless urgently needed, permissible radioactive burdens in the human body.

Case II: In general, the calculation of the dose cannot be considered conveniently without recourse to integral calculus; it can be expressed then as:

$$D_\beta = C \int_R f(\rho)\, dv \qquad (2)$$

where dv is the infinitesimal volume element and $f(\rho)$ is a function expressing the rads at a distance of ρ cm. from a point source of 1 μc while the latter undergoes complete disintegration. The medium is assumed to have unit density, and the integral is extended over the sphere of radius R; C is the concentration common to all points which exhibit radioactivity within this sphere. The numerical value of the function $f(\rho)$ is related to the previous Equation 1 since, in the case of the radioactivity covering the whole sphere, the two expressions must give the same answer. The relationship is obviously:

$$\int_0^R f(\rho)\, d\rho = \frac{73\ \bar{E}_\beta\ T_{eff}}{4\pi} \qquad (2a)$$

Knowledge of $f(\rho)$ is essential to correct estimates, but its direct evaluation requires painstaking experimentation. Thus far, only Loevinger (12, 13), Sommermeyer (14), and Clark *et al.* (15, 16) have reported data on a few emitters. Their findings for P^{32} normalized at zero distance are

TABLE I: RELATIVE VALUES OF $\rho^2 f(\rho)$ FOR P^{32} IN WATER

ρ (mm.)	Ref. 15	Ref. 12	Ref. 14	Ref. 17
0	(1.0)	1.0	1.0	1.0
0.22	1.0	1.0	1.0	0.92
0.45	0.99	1.0	0.99	0.84
1.0	0.96	1.0	0.96	0.67
2.1	0.76	0.76	0.78	0.42
3.4	0.44	0.37	0.53	0.25
4.5	0.20	0.17	0.31	0.16
6.8	0.015	0.03	0.08	0.07

shown in Table I. The results of calculation based on exponential attenuation, adopted by some workers (17–19), are also included for purposes of comparison.

In a rather strict sense, the discrepancies shown therein are serious; in practice, however, these uncertainties would become intolerable only in specific instances of isolated point sources in tissue, such as particulates or colloidal embolisms, and then only when the relative dose must be known at distances comparable to the range of the most energetic electrons.

A simple calculation of general relevance to radiobiology is the estimate of the dose at the center of radioactive volumes of various dimensions, as illustrated in Table II for the case of spheres filled with P^{32}. The doses are therein expressed as a fraction of the dose at equilibrium (Case I). The first column refers to the various forms of $f(\rho)$ assumed, by indicating the references concerned. It is evident that the maximum discrepancies from experiment are found in the case of exponential absorption and then only for very small radii, where the effect of the normalization (Equation 2a) would be more strongly felt. The data also show how closely Loevinger's function (12) represents the experimental values of Clark, at least for P^{32}. From past experience in the subject of dosimetry, however, it can be safely surmised that calculations based on the form of $f(\rho)$, as given by Loevinger, will be lengthy and laborious even for simple geometrical configurations, especially when the dose is computed at points removed from axis of symmetry. In many instances, however, the calculations can be simplified. Thus, for dis-

TABLE II: DOSE AT CENTER OF SPHERES OF VARIOUS DIAMETERS IN PER CENT OF "EQUILIBRIUM" DOSE, ACCORDING TO DIFFERENT FORMS OF $f(\rho)$—WATER MEDIUM

	Radius				
$f(\rho)$	1 μ	10 μ	250 μ	2.5 mm.	25 mm.
Ref. 15	3×10^{-2}	0.3	7.5	67	100
Ref. 12	3×10^{-2}	0.3	7.6	74	100
$\frac{K(R-P)}{\rho^2}$*	3.6×10^{-2}	0.36	8.7	69	100
Ref. 17	4×10^{-2}	0.4	9.5	63	100

* Tried by the author as a rough approximation to the experimental value of Clark *et al.*

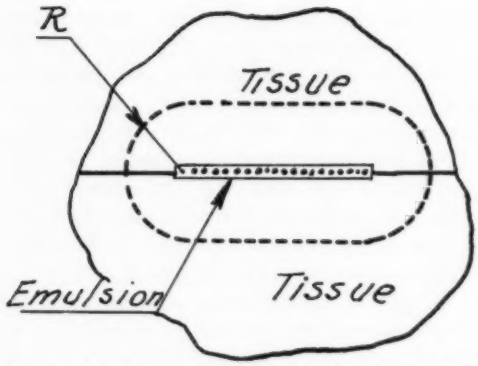

Fig. 1. Idealized set-up for evaluating tissue doses in radioactive tissue by means of single layer emulsion.

tances close to a P^{32} source, the inverse-square law seems to be valid to a high degree of approximation. It follows that in many radiological problems dealing with single cells or microorganisms in very dilute suspensions, the approximation applies.

Likewise, in radioautography, owing to the interest at short distances, the same arguments hold. However, care must be taken to maintain homogeneity in the medium by using thin emulsions of low halide content and by spreading them over supports of low atomic Z, preferably of unit density. It is of interest to note at this point that the radioautographic data of Nadler (20) obtained by flat cylindrical configurations (thyroid follicles containing I^{131}) indicate that $f(\rho)$ varies more slowly than ρ^{-2} at short distances. In view of the agreement mentioned above (12–16) for short distances in homogeneous media (air or Lucite), it is likely that scatter from the microscope slide and the halide of the emulsion may have contributed to the observed results.

The case of non-homogeneous media within the sphere of radius R must be considered as pertaining to another order of complexity irrespective of the spatial variation of C and cannot be approached in general by realistic mathematical methods, since $f(\rho)$ will be a complex function not only of ρ but also of the composition of the medium within the sphere. It should be properly considered only from an experimental point of view as Case III below.

Case III: The more general case may be expressed as:

$$D_\beta = \int C_v f(\rho)\, dv$$

and is much more difficult to calculate, since the value of C_v depends in general on the location of dv and must be determined independently beforehand everywhere within the sphere of radius R. This impasse could be overcome by experimental means; an approach that suggests itself is the use of photographic emulsion because, besides being inexpensive, it has the great advantage of giving dosimetric information in two dimensions.

It is of fundamental importance to ask ourselves whether, in some emulsions, the silver halide grain can play the role which the vanishing cavity plays in ionometric dosimetry. Namely, does it possess the property of requiring, on the average, the absorption of a constant amount of ionizing energy in order to become visible after development? It is obvious that, unlike ionization in gases, once the grain is sensitized, it ceases to function further as a detector; but this disadvantage can easily be overcome if the exposure is small enough to affect only a small percentage of the grains in the emulsion. It is obvious, also, that certain experimental precautions are required if the fading of the image is to be prevented or accounted for. The experimental set-up would be extremely simple, as shown in Figure 1, where two sections of tissue, each thicker than the maximum beta-ray range, surround a detecting emulsion layer.

A search in the recent literature on the number of grains produced by electrons of different energies shows that some photographic emulsions will accommodate our needs, if we use them wisely. In Figure 2, the data of Zajac and Ross (21) on grain counting along electron tracks show conclusively that, for Kodak, Ltd. emulsion type NT4 at least, the proportionality between total grain production and electron energy is rather satisfactory in the region tested. These results have

been confirmed indirectly by Okrent and Solomon (22) in the region below 110 kev with the use of a single grain layer emulsion exposed to monokinetic electrons. In this experiment the blackening of the grain layer was compared with the energy loss of the electrons in the emulsion. 552 film packet. Dudley (25), in an extensive series of measurements, has provided us with valuable dosimetric data on commercially available films exposed to monokinetic electrons as well as to various β-ray emitters. While an adequate summary of his data is not possible at this

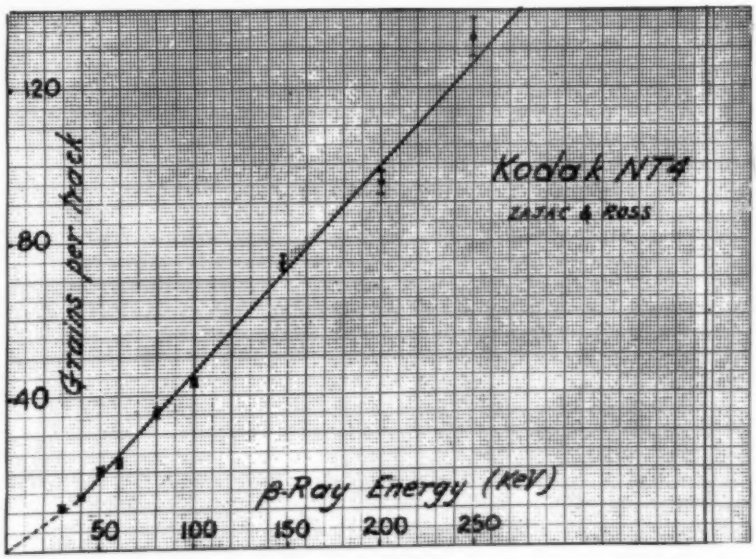

Fig. 2. Total number of grains per track of monoergic electrons plotted as a function of their energy.

Above these energies other evidence, provided by very energetic heavy particles (23), shows that grain production follows closely energy loss. It is indeed comforting to note that, despite the wide variation in experimental conditions, the data (21–23) show that development of a grain of about 0.3 μ diameter requires the dissipation of about 2 kev of energy in electron sensitive emulsions provided the electron energy is higher than 30 kev.

The empirical evidence gathered by comparison of emulsion density to dose in air (determined by means of the extrapolation chamber) is in accord with these findings. Thus Fleeman and Frantz (24) have obtained energy independence of blackening with monokinetic electrons ranging from 0.5 to 1.4 mev striking perpendicularly Minimax Dental x-ray film (extra fast) and DuPont Dosimeter type

time, it will suffice to state that his thinnest film (Cinepositive 5302–2.1 μg/cm.^{2}) shows reasonably constant sensitivity to perpendicularly incident monokinetic electrons down to energies of the order of 40 kev, and that for diffusely incident electrons NTB stripping film gave the best overall dosimetric response within the range of 0.04 to 2 mev.

It should be emphasized that the experiments just mentioned apply to the absolute sensitivity of photographic emulsions to monokinetic electrons and are not exactly representative of the errors likely to occur in dose measurement from beta ray emitters, since in the latter case the energies involved cover a wide spectrum ranging from zero to a maximum energy typical of the radioelement. Thus, by exposing in air Eastman DF-19 film of 2.4 mg./cm.^{2} thickness to various radioisotopes, Tochi-

lin (26) finds constant sensitivity for maximum β-energies greater than 2 mev and a progressive decrease which reaches 50 per cent when the maximum energy is 0.5 mev. More pertinent to our discussion, however, is the comparison (25, 26) of depth doses in suitable phantoms in cases where the latter has been determined ionometrically. The discrepancies observed reach 10 to 25 per cent at depths for which the depth dose is of the order of 10 to 35 per cent, the largest figures applying to S^{35}. In practice, this means that calibration of the film blackening made on top of the phantom holds reasonably well for considerable depths if the radiation is not too soft. Hence, the photographic method is already applicable in many cases, but the calibration must be carried out with the isotope in question (27), and assurance must be had that most of the radioactivity does come from the neighborhood of the films. The accuracy, however, could be improved substantially, and the method confidently applied in practically all instances,[2] if (as in the analogous case of the cavity chamber) we could use routinely emulsions thin enough to absorb only a small amount of the energy carried by the incident particles. This requires the development of emulsions with a single grain layer, judiciously coated to avoid chemical effects at the surface of contact with tissue, and calculation of dose in terms of developed grains per unit weight of emulsion.

The importance of the problem in question and the universality of the method seem to warrant such a development effort, and it is earnestly hoped that the active interest of film manufacturers can be secured for the purpose.

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SUMARIO

Dosimetría de la Irradiación de Emisores de Rayos Beta Administrados Internamente: Estado Actual y Expectativas

La valuación de la dosis absorbida en medios biológicos que contienen isotopos radioactivos ha sido objeto de algunos excelentes estudios. Este trabajo sumariza el estado actual del tema en lo tocante a los emisores de rayos beta.

Se aborda el problema considerando la dosis en un punto dado, P, en un medio bajo tres condiciones generales, a saber:

Caso I. El punto queda dentro de un medio homogéneo que contiene una concentración uniforme de radioelemento, que se extiende desde P hasta una distancia mayor que el límite, R, de la partícula más enérgica emitida por el isotopo.

Caso II. Dentro de una superficie esférica del radio R, el punto en cuestión sólo está rodeado parcialmente por una o más zonas de concentración uniforme.

Caso III. Dentro de la misma esfera, la concentración no es uniforme, independientemente del espacio que ocupe la zona radioactiva.

DISCUSSION OF SYMPOSIUM ON RADIATION UNITS

Edith H. Quimby, Sc.D. (New York, N. Y.): This group of very satisfactory papers should do much toward clarifying and organizing our concept of radiation measurement. The whole subject has been developing so rapidly in recent years that it is often hard to keep up with it. Mr. Parker's paper is most helpful from this point of view.

We have followed the development and decline of the roentgen, with mixed feelings. It was, and is, a convenient unit for radiation therapy, even though it did not strictly describe either the intensity of the beam in air or the absorbed dose in tissue. We learned to make it serve, and we even developed a concept of an "equivalent roentgen" for β particles closely akin to the rep.

The Bragg-Gray Principle remained for many of us something of rather academic interest—the physicists liked it and it didn't bother the radiologists. However, there has been increasingly a rather uneasy acceptance of the fact that in therapy, or in the production of any radiobiological reaction, the effect is due to the energy absorption in the cells at the region of interest, and that therefore dose should be related to ergs absorbed per gram of the medium—of tissue in the case of therapy. A conversion factor was accepted of 93 ergs per gram of soft tissue or of 84 ergs per gram of air. The existence of these two different conversion factors, and the realization that for other tissues other factors would necessarily exist, were bothersome.

Now it is in a sense a relief to know that at a bold stroke all these confused units and conversion factors for absorbed dose are swept aside (at least to a degree) and one new unit established, the rad, 100 ergs per gram of whatever the absorbing medium. Obviously there can be no constant relationship between roentgens and rads; it will generally take more roentgens to provide 1 rad to soft tissue than to bone. However, we can look for definite tables of data applicable to this problem. For a while we are going to have to watch our step in changing back and forth between roentgens and rads. Actually, I am sure there will be no immediate wholesale abandonment of the roentgen for describing tissue dose. But the approximation that 1 rad (= 100 ergs) is *about* the energy absorbed by tissue when it is exposed to 1 roentgen of x-radiation will facilitate the acceptance of the new unit and of the more accurate conversion factors as they are forthcoming.

The concept of the rem and the idea of relative biological effectiveness of different kinds of radiations become of greater and greater importance, particularly in protection problems with mixed types of radiation.

Dr. Laughlin's paper logically follows Mr. Parker's. He has now separated the two measuring problems, the intensity of the radiation and the absorbed dose. As he says, we have loosely—but conveniently—used the roentgen as the unit for each, when actually it isn't a unit of either. Theoretically there are rather simple relationships be-

tween the roentgen as measured in air and the energy flux in ergs per square centimeter per second. Also there is a relationship between the ionization measured in a small cavity-type ionization chamber within a medium and the energy absorbed in the material surrounding the cavity. Dr. Laughlin has analyzed these relationships and then has gone on to the matter of the direct determination of the two aspects of the radiation.

Various attempts at calorimetric measurement of radiation intensity have been made for many years. Theoretically it is very simple; you just put enough heavy metal in the beam to absorb the entire energy and measure how hot the metal gets. Practically, the experimental difficulties are great, and Dr. Laughlin's simple statement of what he got tells very little of the effort involved.

The immediate steps from the survey in the phantom with an ionization chamber or scintillating crystal must be appreciated. It is again necessary to have a sufficiently large mass of matter to absorb all the energy, and then relate individual readings to the total absorption. Ordinary phantom measurements are insufficient.

The extension of such measurements to electron beams takes on new importance with the availability of high-energy charged particles for experimental work, and eventually for therapy.

Miss Focht's paper should perhaps have followed Dr. Laughlin's, since it represents a special phase of the dosage problem. We have all been aware of the differences in skin reaction to different qualities of radiation. The known factors of back-scatter and of varying depths of the position of electron equilibrium have not been sufficient to explain them. In attacking the problem at the basic level, Miss Focht offers encouragement that we may find some more real reason for the variations than the rather meaningless statement that it is a "quality effect of radiation."

Mr. Marinelli is concerned with a problem of concern to many of us, the dosage from radioisotopes distributed irregularly in tissues. His first case, of uniform distribution, is rather easy theoretically, and probably non-existent practically. (If you have been disturbed by the appearance of 73 in the formula where you have been used to seeing 88, this is due to the shift from equivalent roentgens to rads.)

His second case also has little practical importance, since it is concerned with phenomena at the surface of separation between uniform concentration and no concentration.

The third case is the one we all want to know more about. We are accustomed to having Mr. Marinelli develop rather complicated mathematics and then come up with straightforward and useful tables of data. This time he has also come up with the suggestion of a new experimental approach to this problem, using photographic emulsions—not an easy approach but one that should be fruitful. We will look forward to hearing more of this.

I am sure you are all as disappointed as I am that Dr. Taylor could not be here to present his report in person. This is a report we have been waiting for ever since the first home-comers from the International Congress started telling us about the new unit, the rad. Dr. Parker has already explained it for us, and now we have the official statement for this, as well as for other actions of the Commission.[1] Little can be added to this report by way of comment; it is one that will merit careful study.

I do want to express my appreciation—and I am sure the appreciation of the entire audience—to the essayists this morning for a most interesting and informative group of papers.

Robert R. Newell, M.D. (San Francisco, Calif.): These authors have presented ideas that would keep a bull session going far into the night. Herbert Parker accepts with good grace the metamorphosis of his *rep* into the new *rad*. It's good to have him explain how it is measurable.

Elizabeth Focht's concern with surface dose is no more lively than ours. But surface dose gets a disproportionate amount of attention. There was a time when the skin erythema was all the radiation therapist had to lean on for dosage measurement. And for half a century the skin injury was the practical limiting factor for deep therapy. Lately, however, we have machines and technics for getting what dose we need into the middle without compromising the skin. The physiology of skin reaction is not too fully understood and we are disturbed by the discrepancy between observed erythema from presumably similar doses from x-ray and from the gamma irradiation. We might well do what dermatologists have long done with unfiltered radium plaques, *viz.*, measure the dose in seconds on the basis of clinical experience, without reference to any other physical measurement.

I agree with John Laughlin that the habit of using the roentgen as a unit of tissue dose has done harm to radiation therapy. But I think this bad habit arose, not from using thimble chambers, but rather because in 1927 we couldn't get the physicists to measure the dose, which we wanted, so we accepted the unit of exposure, which they *could* measure. Most of the modern problems Dr. Laughlin has discussed arise from advances into the multimegavolt region, where I have no experience. His remarks about specific ionization in electron beams have as yet but little clinical application, because no electron beams are available for therapy that are anything near monoenergetic.

As pointed out by both of these essayists, it is lucky that we are reaching an energy region where bone is not given a dose so disproportionate to the soft-tissue dose. The designation of ion density

[1] See Radiology **62:** 106–109, 1954.

along the electron path (I'd prefer to call it columnar density) by its average may not be too well correlated with biologic effect. Perhaps it would be more to the point to count the paths, not average them, because of the overwhelmingly high biologic efficiency of their densely ionized termini.

Leo Marinelli goes deeply into the theory of beta energy absorption from tissue concentrations of isotopes. We shall be using his results as formulae, whether or not we follow his discussion.

The decisions of the International Committee reported by Dr. Taylor are of great practical importance. It is good indeed to have a unit uniquely devoted to physical dose (specific absorption of radiant energy). I hope the editors of RADIOLOGY will blue-pencil all reports of tissue dose, skin dose, and tumor dose in roentgens and make the authors compute these in rads. Let's have roentgens used hereafter only in the defined meaning of exposure, let the tissue do with it what it will! It's a relief to find the International Committee developing a realistic attitude toward blood counts, appreciating the fact that they are a diagnostic test pertinent to persons possibly injured by radiation, but of no use in discharging our duty to see that none is injured in the first place.

I have long been interested in the dimensions and names of units. I shall send a letter to the Editor about the impact of the new units on our language and records.[1]

Harold O. Wyckoff, Ph.D. (Washington, D. C.): Last summer when I left for Europe I thought this program was all settled. After I came back I found I was listed as a discussant.

I think the only thing I would like to say is that we have now a definition of "absorbed dose," rather than being, shall I say, sloppy, as we have been in the past, and just saying "dose," because *dose* has a number of other connotations.

Then I would like to make a distinction between the measurement in *roentgens* and the measurement in *absorbed dose*. In roentgens we make a measurement of the ionization per unit volume essentially of air in an air-wall cavity. In measuring absorbed dose we are concerned with the amount of energy at the point of interest; so we measure the ionization per cubic centimeter of any gas that we wish and by knowing the constants involved we can compute the energy absorbed in the surrounding material. The wall of this cavity is not necessarily of air but it is of the material in which you are interested.

[1] See page 743 of this issue of RADIOLOGY. Also Editorial, page 741.

Panel Discussion on Low Back Pain

Objectives of the Preplacement X-Ray Investigation of the Low-Back Area[1]

JOHN R. WINSTON, M.D.,[2] and ROBERT D. MORETON, M.D., F.A.C.R.[3]

THE ESSENTIALLY rural economy that prevailed in the early history of our nation was no less in need of man power than is our industrial economy of today. Our predecessors met the problem in a way that was perhaps more philosophical than scientific. Communities were small. Through personal acquaintance the special aptitudes and weaknesses of the individual were known to the group. Perhaps it is trite to say that survival of the community, as well as the individual, depended upon proper use of this information. Thus, information gained with much effort by the employer today was at that time common knowledge.

In recent years the medical literature has given considerable space to various examination programs for workers in industry. Our military experience in this generation has amplified the use of the scientific approach to proper placement and maintenance of personnel in positions where they will be most productive. And now at least one governmental agency has been using a measuring stick of this type to determine which of its employees shall be retained in service incident to curtailment of its program. These efforts represent our scientific attack upon the problem of more satisfactory placement and maintenance of our industrial population.

Pre-employment physical examinations had their inception some forty years ago, and have now become well standardized. X-ray investigation of the low back area as part of the pre-employment examination has been used only sporadically in the past, and then only by a few industries. At the present time this practice is becoming more widespread but it is by no means a generally accepted or stabilized procedure.

Because the greatest number of man-hours lost from work on account of back complaints occurs in a relatively small segment of our employees (Atchison, Topeka & Santa Fe Railway System), a program of x-ray investigation of prospective employees in these jobs was undertaken. Many plans, ranging from a single anteroposterior view of the lumbar area to roentgen investigation of the entire spine, are being used in other surveys of this type. Since most back complaints are confined to the low back area and most lesions demonstrated by x-ray investigation are at the fourth and fifth lumbar and first sacral segments, it was concluded that these areas would hold the center of our attention, although the adjacent areas were also to be observed. To accomplish this in a survey type of investigation, it was concluded that four views would suffice, namely, anteroposterior, lateral, and right and left 45-degree obliques.

It was decided to grade the various abnormalities into four groups. Thus all prospective employees examined under this program would fall into one of the following classifications:

Class I: No abnormalities.
Class II: Abnormalities not associated with clinical back complaints.
Class III: Abnormalities rarely associated with clinical back complaints.
Class IV: Abnormalities occasionally associated with clinical back complaints.
Class V: Abnormalities often associated with clinical back complaints.

A list of the pathological conditions

[1] Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13–18, 1953.

[2] Medical Director, Atchison, Topeka & Santa Fe Railway System.

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that we expected to find was given to a number of orthopedists and other physicians with considerable experience in industrial medical problems. They were kind enough to give us their opinions as to what place in this proposed classification each abnormality should be listed. Our present classification represents a composite of the views expressed by these physicians, as well as information gained from the medical literature, the details of which do not apply to this presentation.

Inquiry into surveys of this type now being conducted showed lack of uniformity as to the handling of the various abnormalities. Often a list of pathologic conditions was given the roentgenologist, who was asked to disqualify for service those applicants showing such abnormalities. In many cases the x-ray examinations were not done by roentgenologists, and the examining physician used his own judgment as to a man's acceptability for employment. It is readily understandable that on occasion misunderstandings would occur between the employing officer and the examining physician as to what constituted satisfactory physical standards for a given assignment. It was decided that in our survey we should not only specify the type of roentgen investigation the prospective employee should have, but also that we should not ask the radiologist or the examining physician to act as final judge, but that we should rather give the hiring officer the benefit of our combined findings, along with certain standards that would enable him to appraise more satisfactorily the applicant at hand. Through this arrangement, the radiologist would not be called upon to correlate roentgen findings with the applicant's clinical status and the physical requirements of the job in question. On the other hand, neither would the employing officer be required to interpret medical terminology in terms of the job requirements of the person examined.

In military service, standards as to physical requirements for duty have been modified from time to time. These modifications have depended on the need for military personnel, and as additional experience was gained from the plans previously in effect, changes appeared to be in order. It is reasonable to assume, therefore, that as our information increases, we also will feel justified in making certain changes in the classifications presently in use.

Our present practice is to refer the prospective employee for x-ray examination of the low back area after he has passed a satisfactory physical examination for the class of service in question. The radiologist is asked to make the proper classification, depending on the radiographic findings. Examination of the wet film is desirable for two reasons. First, technical defects in the examination can be found and corrected, whereas it would often be impossible to re-examine the applicant at a later date. Secondly, the employing officer can be advised by telephone of the applicant's tentative classification, whereas the delay involved in transmitting the usual written report by mail may cause the applicant to seek employment elsewhere, or delay his accepting a more favorable type of employment should it be concluded that the x-ray findings preclude his employment in the class of service applied for.

We should not lose sight of the objective of the roentgenologic investigation of the low back area as part of the preplacement physical examination. To bring about the most satisfactory utilization of all available man power, it is necessary that each person be placed in a job that is most compatible with his capabilities. A program of this type is undertaken with the hope of helping to accomplish these objectives. All preplacement examinations, whether physical, psychological, aptitude, or radiological, are designed to further this objective and thereby protect the safety, well-being, and earning capacity of not only the employee and employer, but of his fellow workers as well.

Santa Fe Station
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SUMARIO

Objetivos de la Investigación Roentgenológica Prevocacional de la Zona Inferior del Raquis

Para lograr la utilización más satisfactoria de toda la mano de obra industrial disponible, es necesario que cada persona sea colocada en el oficio más compatible con sus capacidades. La investigación roentgenológica prevocacional de la zona dorsal inferior tiene por fin adelantar ese objetivo.

Clasifícanse en la forma siguiente las varias anomalías que pueden observarse en la porción inferior del dorso: anomalías que no van acompañadas de síntomas clínicos; anomalías rara vez acompañadas de síntomas clínicos; anomalías acompañadas de cuando en cuando de síntomas clínicos; anomalías acompañadas a menudo de síntomas clínicos. Otra clase más comprende los casos sin anomalías. En un caso dado, el radiólogo verifica la clasificación y comunica el resultado al funcionario encargado, a quien corresponde decidir lo relativo a empleo del aspirante.

Panel Discussion on Low Back Pain

Radiologic Considerations in Preplacement Examinations of the Lumbar Spine

Summary of Four Thousand Consecutive Cases[1]

ROBERT D. MORETON, M.D.,[2] JOHN R. WINSTON, M.D.,[2] DOUGLAS E. BIBBY, M.D.,[3] and CLAUDE WILLIAMS, M.D.[2]

IN SETTING up a program for interpretation of the radiographs of the low back it was immediately realized that some specific rules would have to be established that would be uniform, easily adhered to, and adequately interpreted. One of the main conditions requiring this attention was spondylolisthesis. For this paper we will limit ourselves to the classification used in reporting this defect, its incidence, and that of isthmus defects, as noted in 4,000 consecutive pre-employment radiographic examinations of the low back.

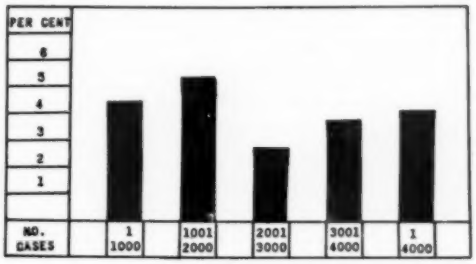

Fig. 1. Incidence of spondylolisthesis in groups of 1,000, as well as for the total 4,000 consecutive examinations.

As Dr. Winston has explained (p. 664), the views obtained included anteroposterior, lateral, and right and left posterior obliques. The anteroposterior and lateral views were made on 14 × 17-inch films, with the latter view centered 1 1/2 inches below the crest of the ilium. The oblique views, on 10 × 12-inch films, were centered at the lumbosacral interspace. These radiographs were all interpreted twice, with a review of any in which there had been a difference of classification.

It is essential that certain standards of reporting be established so that the report sent to the Medical Director be adequately understood. Realizing that occasionally we have foreshortened vertebral bodies, we decided to use the perpendicular line test which was originally described by Ullmann, but more recently by Garland. We refer to this, for the sake of adequate reporting, as the "Garland sign." We well realize that with this criterion a few instances of spondylolisthesis may not be reported as such, but feel sure that all instances measuring up to this standard will be true spondylolisthesis. We have seen instances in which this entity has been reported on the original interpretation but did not fulfill the perpendicular line requirements. In our final report and classification such cases were classed as isthmus defects, without spondylolisthesis according to the Garland sign. Thus, the reader knows that the defects were present but that the vertebral body had not slipped far enough to touch the perpendicular line from the anterior superior tip of the vertebral body just below. Using this criterion, we found the incidence of spondylolisthesis in our series to vary from 2.7 to 5.3 per cent per thousand (Fig. 1). We regard this as a normal variation in groups of 1,000 relatively young men and believe that it certainly represents the percentage of true anterior slip according to the perpendicular line test. The incidence for the entire group is slightly below that found by Friedman, Fischer and Van Demark, Bailey, and others. The last

[1] Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13–18, 1953.

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TABLE I: INCIDENCE OF SPONDYLOLISTHESIS WITH VERTEBRAE AFFECTED IN EACH GROUP

No. Patients	Incidence	Vertebra Involved 4th	5th	6th	Per Cent Last Lumbar
1–1,000	44	3	39	2	93
1,001–2,000	52	1	50	1	98
2,001–3,000	27	1	25	1	92
3,001–4,000	37	...	35	2	100
1–4,000	160	5	149	6	97

lumbar vertebra was found to be by far the most frequently involved (Table I). As will be noted, we found no spondylolisthesis above the fourth lumbar vertebra, according to the perpendicular line test. The percentage of involvement of the last lumbar vertebra seems to be somewhat higher than reported in other series, but the exactness of the test line may be of some significance in this determination.

In grading the amount of slip, we again tried to establish a system that we could reconstruct graphically. The grading I through IV depending on the measurement of the superior surface of the sacrum or adjacent vertebrae (10) seemed to have disadvantages. The vertebral bodies normally vary in their anteroposterior measurements and, therefore, a true Grade I or II in one instance will not be the same in another, as measured in millimeters. Also, reports of several competent radiologists showed variations in their consideration of this grading. After some discussion, therefore, it was decided that the condition could best be recorded by measuring the angle formed along the posterior surface of the vertebra involved. This method has been described by Meschan. (*a*) A line is drawn between the posterior lower lip of the vertebral body above the one involved to the posterior upper lip of the vertebral body below. (*b*) Another line is drawn between the posterior upper and lower lips of the slipped vertebral body. (*c*) The lines are extended, if they are not parallel, so that they meet and form a measurable angle. The position of the apex of the angle is considered characteristic for spondylolisthesis. Garland found this method not to be as accurate as the perpendicular line test for spondylolisthesis, but we feel that it is very satisfactory in describing the type of slip present, after the line test has been fulfilled. (*d*) The angle between these two lines is measured with a protractor. If the lines are parallel, the linear distance between them is measured. We do not attempt further grading as slight, moderate, or severe.

For interest, we measured the posterior edge of the interspace between the fourth and fifth lumbar vertebrae, the fifth lumbar and first sacral vertebrae, and the height of the posterior portion of the body of the fifth lumbar. The averages found in one hundred such measurements were 9 mm., 8 mm., and 32 mm., respectively. If the interspaces were not considered narrow in the interpretation, then we tried using these figures to reproduce our findings more accurately.

We feel that using the foregoing information and index system only, we can reproduce fairly accurately the type and degree of slip present (Fig. 2D). A linear slip with parallel lines is reported as an anterior slip of a certain number of millimeters (Fig. 2A). In case the lower border of the vertebrae has slipped more than the upper, which is by far the most frequent type, we refer to an angle of so many degrees (Fig. 2B). If, as has seldom occurred in our experience, the upper portion has slipped more than the lower, we list this as showing a reverse angle of a certain number of degrees (Fig. 2C). Meschan feels that a slip is not present if the angle forms below the involved vertebrae. However, we encountered 2 such cases.

It must be realized that in some instances in such a routine preplacement survey, the men may not be as carefully positioned for the oblique views as would be expected with private patients complaining of low back pain. In general, however, the radiographs have been quite satisfactory, and many examiners have obtained additional views when suspicious defects were noted. In this series of 4,000 cases, the presence of defects of the pars interarticularis has been confirmed by at least two radiologists. There were found to be a total of 272 isth-

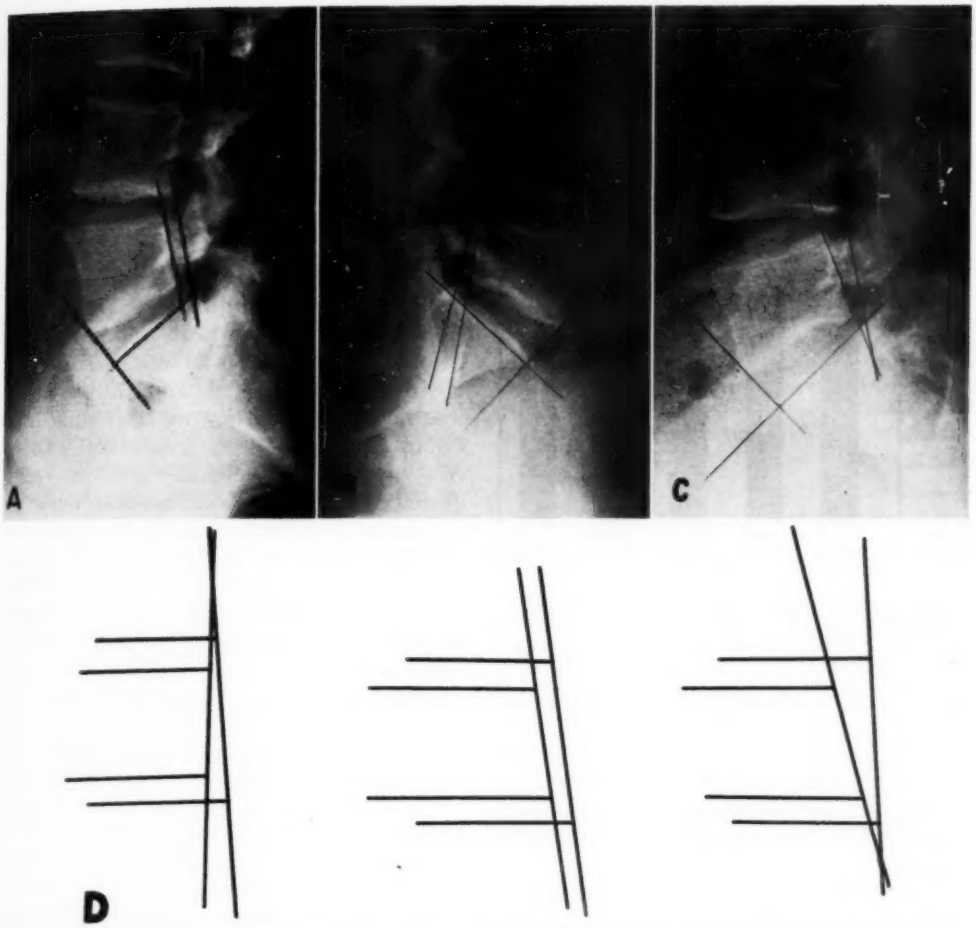

Fig. 2. Instances of spondylolisthesis, illustrating the positive perpendicular line test (Garland sign) and the system used in describing the type of spondylolisthesis according to Meschan's method.

A. The involved vertebra has slipped with its posterior edges remaining in the same plane parallel to the test line.

B. The most frequent type of spondylolisthesis, in which the inferior portion of the involved vertebra has slipped more than the superior. An angle is formed with the line from the adjacent uninvolved vertebra.

C. Unusual type, in which the superior portion of the involved vertebra has slipped more than the inferior portion. This is referred to as a reverse angle, being opposite to that most frequently observed (B).

D. Diagrams illustrating the type and amount of slip. This can be easily determined from a simple report and illustrates quickly the type of spondylolisthesis present in each instance.

mus defects in the entire group. These are broken down in groups of a thousand each in Figure 3. The variation in incidence shown in this chart is well within limits shown by Rowe and Roche in their Table, in which the percentage ranged from 3.5 to 10.6.

It was of some interest to note that the variation in the presence of isthmus defects was in about the same proportion as noted with spondylolisthesis. There were 3 per cent more isthmus defects in the first thousand examinations, 2.8 per cent in the second thousand, 2.9 per cent in the third thousand, and 2.4 per cent in the fourth thousand. The location of the

TABLE II: LUMBAR VERTEBRAE INVOLVED WITH ISTHMUS DEFECTS IN GROUPS OF 1,000, AS WELL AS SUMMARY OF ENTIRE SERIES

No. Cases	Vertebra Involved			
	3d	4th	5th	6th
1–1,000	3 (4%)	5 (7%)	61 (82%)	5 (7%)
1,001–2,000	4 (5%)	2 (2.5%)	73 (90%)	2 (2.5%)
2,001–3,000	1 (2%)	4 (7%)	49 (87%)	2 (4%)
3,001–4,000	1 (1.6%)	4 (7%)	54 (88%)	2 (3.4%)
1–4,000	9 (3.3%)	15 (5.5%)	237 (87%)	11 (4.2%)

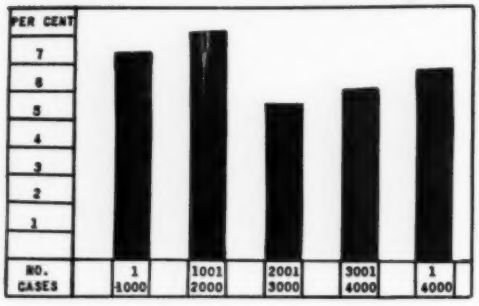

Fig. 3. The distribution of isthmus defects shown in groups of 1,000 and for the entire group of preplacement examinations.

defects was primarily in the lower lumbar vertebrae, just as in the case of spondylolisthesis, as would be expected; 91.2 per cent were found in the last lumbar segment. A complete summary of the incidence in the various groups is shown in Table II.

Our findings as to the type of defect, confirmed those of Garland and others, in that over half, or 67 per cent, were bilateral. There was some variation in the different groups, but the general trend, as shown in Table III, will be found to be the same.

We do not try to vary the preplacement classifications between those having isthmus defects and spondylolisthesis. We feel that the former are necessary to produce the latter, and certainly these men should be protected from repeated trauma and strain if possible. Also, most men in this category are taking long-range positions, and the weakening of muscles and ligaments from age or disease will predispose to such a slip in the presence of a vertebral segment with a defect in the neural arch.

The cause of the defects is still unknown in the majority of instances. Due to the smooth and symmetrical appearance of the defects a congenital origin has been postulated (1, 3). At first, however, it was believed that they were traumatic in origin (6, 8). Roberts reviewed the theories of Meyer-Burgedorff and has suggested that strain deossification may be the cause of the separation by a mechanism similar to that of the fatigue or "march" fracture. Rowe and Roche feel that this might occur during the formative years, or perhaps even later with the onset of manual labor. They further believe that Thieme's conclusion, that the defect is related to the lumbar curve and upright posture, may be interpreted as support of this line of reasoning.

TABLE III: TYPES OF ISTHMUS DEFECTS FOUND IN THE PREPLACEMENT EXAMINATIONS

No. Cases	Bilateral	Right	Left
1–1,000	40 (54%)	22 (30%)	12 (16%)
1,001–2,000	52 (64%)	15 (19%)	14 (17%)
2,001–3,000	39 (69%)	10 (18%)	7 (13%)
3,001–4,000	53 (86%)	3 (5%)	5 (9%)
1–4,000	184 (67%)	50 (19%)	38 (14%)

All the men covered by our survey denied any history of injury or backache at the time of their physical examination. For these reasons we have tried to evaluate the isthmus and have classified the narrow isthmus in a higher group. We feel that this is more important when associated with an increase in the sacral angle as measured by Ferguson, since the weight-bearing tends to be more on the isthmus. If these latter theories are correct, gradual fragmentation and dissolution leading to neural arch separation might be more likely. With this in mind, we found that

the percentages in this group varied from 3.1 to 4.4 per thousand (Fig. 4). We well realize that such an assumption cannot be based on definite proof, but we do feel that it has a basis for consideration and study.

SUMMARY

An attempt was made to set up a uniform reporting system for preplacement examinations of the lumbar spine as related to spondylolisthesis and neural arch defects, for industrial purposes. As a criterion for spondylolisthesis the perpendicular-line test or Garland sign was used, according to which the vertebral body must have slipped sufficiently to touch a perpendicular line from the anterior tip of the vertebral body just below. Upon this basis the incidence of spondylolisthesis in 4,000 examinations was from 2.7 to 5.3 per cent per 1,000, or about 4 per cent for the 4,000 cases. The last lumbar segment was involved in the highest percentage of cases.

For grading the amount of slip, Meschan's method of measuring the angle formed along the posterior surface of the involved vertebra was employed.

There were found to be 272 isthmus defects in the 4,000 cases surveyed. Most of these were bilateral and affected the last lumbar vertebra. About 2.8 per cent were unassociated with spondylolisthesis.

The etiology of isthmus defects is discussed. Since most of the men examined gave no history of injury or backache, an attempt was made to evaluate the isthmus. With a narrow sclerotic neural arch, especially in association with an increased sacral angle, there appears to be a tendency for weight-bearing to be more upon the isthmus, and eventual neural arch separation becomes more likely.

It is realized that further experience may make necessary a rearrangement of this program, and that several years may be required to evaluate it adequately.

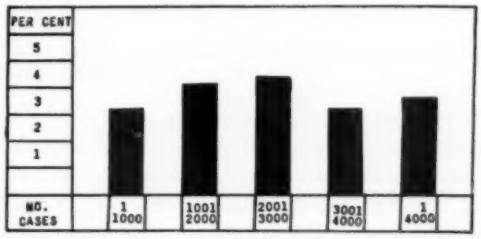

Fig. 4. Incidence of narrow neural arch associated in most instances with an increase in the sacral angle.

RECOGNITION: We want to recognize the radiologists associated in carrying out this program. Without their interest and splendid co-operation it would not be possible. Space does not permit naming each one, but it is hoped in time each may be properly recognized. Until then we sincerely appreciate their help.

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(Para el sumario en español, véase la página siguiente)

SUMARIO

Consideraciones Radiológicas en los Exámenes Prevocacionales de la Porción Lumbar del Raquis: Sumario de 4,000 Casos Consecutivos

Trátose de establecer un sistema uniforme de descripción para los exámenes preocupacionales de la porción lumbar de la espina dorsal en la industria, en su relación con la existencia de espondilolístesis y de defectos de los arcos neurales. Como pauta para la espondilolístesis, se usó la prueba de la línea perpendicular o signo de Garland, conforme al cual el cuerpo vertebral tiene que haberse deslizado lo suficiente para tocar una línea perpendicular trazada desde el extremo anterior del cuerpo vertebral que queda precisamente debajo. Sobre esa base, la incidencia de espondilolístesis en 4,000 exámenes fué de 2.7 a 5.3 por ciento in cada 1,000 casos, o sea approximadamente de 4 por ciento para los 4,000 casos. El último segmento lumbar fué el afectado en el porcentaje mayor de casos.

Para graduar la proporción de deslizamiento, se empleó el método de Meschan de medir el ángulo formado a lo largo de la cara posterior de la vértebra afectada.

En los 4,000 casos estudiados, se descubrieron 272 defectos del istmo. La mayor parte eran bilaterales y afectaban la última vértebra lumbar. En 2.8 por ciento aproximadamente, no había asociación con espondilolístesis.

Discútese la etiología de los defectos ístmicos. Como la mayoría de los sujetos examinados no comunicaron historia de lesión o raquialgía, no se trató de justipreciar el istmo. Con un arco neural esclerótico estrecho, en particular si va unido a un aumento del ángulo sacro, parece existir tendencia a cargar el peso más sobre el istmo, y se vuelve más probable la separación eventual del arco neural.

Se comprende que nuevas observaciones tal vez obliguen a modificar este plan y que quizás se requieran varios años para justipreciarlo debidamente.

Panel Discussion on Low Back Pain

Medicolegal Radiology[1]

CHARLES L. EWING[2]

THE PROBABILITY that any case referred to the radiologist today involves a medicolegal problem is so great that he should gear all of his procedures with that probability in mind. The fact that we are living in a claim age needs little support. To quote from a New York judge: "The paradox of the 'claim age' is that lawyers discover injuries and doctors find legal liability." The radiologist cannot assume that a case involves no medicolegal aspects even though his part of the examination reveals no injury. The most popular claims are those in fields wherein the medical profession is none too certain with respect to either diagnosis or prognosis. It is this characteristic that makes back cases so popular. On the Santa Fe, for the year 1951, 41 per cent of all cases in suit involved a claim of back injury. From the standpoint of volume, however, railroad injuries are a mere drop in the bucket. Think of the thousands of automobile cases that reach our courts every year, the innumerable claims for industrial compensation, the claims on accident and health policies, to say nothing of a considerable volume of malpractice cases. Can there be any doubt of the probability of every case involving a medicolegal problem?

Assuming this rather obvious fact to be true, in what respect is it necessary or desirable for those engaged in the specialty of radiology to change present practices and procedures? I assume that most of you are not attracted to medicolegal practice as such; that you have no desire to become professional expert witnesses, but that your principal concern is diagnosis and treatment. I am also assuming that you do not consider the Hippocratic oath to require you to become advocates for your patients in all of their efforts to secure monetary balm whenever and wherever they seek it. Would it be fair to say that you would like to have your professional accomplishments and your testimony, when necessary, reflect your honest medical opinion without distortion, without unwarranted inferences, and certainly without embarrassment to you personally? That would seem a simple thing for men who have reached the proficiency in their specialty that is evidenced by your membership in this Society. Surprisingly enough, that result is not as easy to attain as you may think. The very terminology which you use in some of your reports may result in total distortion of your opinion. An extreme example occurred in a case tried in California, in which an alleged head injury was involved. The only claim made even by the plaintiff was a moderate concussion. In spite of this, the jury returned an exorbitant verdict. The foreman of the jury was asked how he arrived at the absurd result. He pointed to the clinical record, which contained the note "rule out fracture." He said: "Don't you think you should pay that much for a man whose head is so badly broken as to have a rule-out fracture?" That is an example of the kind of interpretation that can be placed upon inadvertent remarks appearing in x-ray reports and hospital records.

One of the most common expressions that I have come across in x-ray interpretations is "old fracture." It has seemed to me and to others whom I have consulted that "old fracture" can apply to anything which has occurred thirty days or more prior to the examination and may go back

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[1] Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13–18, 1953.

[2] General Claims Attorney, Atchison, Topeka & Santa Fe Railway System.

as much as fifty years. Frequently in examining successive reports on the same patient who has actually had some type of fracture, we find repeated references to the fracture in the clinical record, x-ray interpretations, and specialists' reports, and then suddenly in a late report of a radiologist we come upon the words "old fracture." I suspect that the plaintiff's attorney is startled when he sees such a report referring to the specific injury for which his client is being treated, and that the defense attorney has false hopes raised when that term comes into the picture. It may be that when a fracture has healed it is impossible to say how old it is. Even if that be true, the use of the word "old" with respect to a fracture incurred less than three years earlier can be confusing and misleading to juries and lawyers. I notice that some of you use the term "healed fracture." I think this is preferable, but it also seems reasonable to suggest that some effort be made to indicate whether the fracture is one having to do with the patient's present difficulties as shown by his clinical record or if it is some entirely irrelevant injury.

Another stock phrase which seems to be a favorite with radiologists, and which has been embarrassing to many of us from a legal standpoint, is "no definite evidence" of fracture, dislocation, or other bone pathology, etc., or "no significant bone anomalies." I presume that the doctor who uses those terms must use them out of an abundance of caution or in fear that someone will find some evidence that he must protect himself against. Undoubtedly, the man who uses those qualifying words "definite" or "significant" feels that he has done no harm, since his principal finding is negative. Think for a minute, however, of the impact of that language in the trial of a case where doctors have become advocates. Unfortunately, that can happen. Assume that some doctor does claim to have found evidence of fracture. Just what is your opinion then worth? You say you have found no definite or significant evidence, the reverse of that statement is that you have found *some* evidence. Before a jury, if you have found some evidence or some anomalies and the claimant's doctor has found more evidence or more anomalies, your negative report has turned into a positive report. If it is your desire to be fair and impartial from a medicolegal standpoint and to have your opinion given the weight to which it is entitled in the trial of a personal injury case, I beseech you to make your findings positive. State exactly what you do find and exactly what you do not find. Do not use weasel words!

There is the other type of report, which makes a positive statement, such as "I see no evidence of bony trauma or disease," but continues on to describe beginning arthritic changes, narrowing of the intervertebral disk possibly with the added notation that "this is suggestive of a herniated disk" or "there is definite evidence of a spondylolisthesis with slight forward displacement of the 4th lumbar on the 5th, probably not connected with the injury," etc., mentioning multitudinous non-traumatic conditions. Once again, the doctor has left himself open to a complete misinterpretation of his report by the use of this inexact language. He has given his opinion, namely, that there is no evidence of bony injury or disease, but he has inserted a world of information that a claimant's attorney can analyze, develop theories about, and probably find other doctors to testify concerning, with the result that his report when presented to a jury will prove the exact opposite of the findings. It would seem to me that a cardinal principle in writing a report of an x-ray examination should be to answer these questions: Does it accurately and positively represent the radiologist's opinion? Is it susceptible to interpretation or even a reverse interpretation in the hands not only of specialists, but of lawyers and juries? I would suggest that a report of an x-ray examination where any trauma is involved, should be under two headings: the findings concerning trauma and the findings which bear no relationship to trauma. For

example a report might read as follows:

1. X-ray findings where trauma is involved.
   (*a*) None *or*
   (*b*) There is evidence of a compression fracture of the 12th dorsal vertebra.
2. Other x-ray findings not connected in any way with trauma.
   (*a*) Arthritic changes.
   (*b*) Congenital anomalies.

Again I say the radiologist should be careful in his reports and in his opinions to keep in mind the fact that they may be used by many people in addition to the doctors who consulted him and may be susceptible to laymen's interpretations.

While it may at first seem rather fundamental, I cannot forego this opportunity to call attention to the necessity for accuracy in the identification of roentgenograms and in their interpretation. It is absolutely essential from a legal standpoint that evidence be incorporated within the film itself, as to identity of the patient and the date of examination. This practice has become more common in recent years than it was in the past, but on the mere chance that any of you have overlooked it, I again call it to your attention.

Accuracy in film interpretation would seem to be within your professional field and not to warrant comment on my part. However, inaccuracies may creep in where they are unimportant from a medical standpoint. I can never forget an instance which was extremely costly to me in time and to my company in money through an error in the counting of the vertebrae in a particular case. I was involved in litigation wherein a compression fracture was claimed. My x-ray report verified a compression fracture of the 5th lumbar at the juncture with the 4th. In running down the claimant's history I was elated to see that this man had received an award of compensation in Seattle, Wash., on account of a compression fracture of the 5th lumbar vertebra. It looked like another case of someone trying to collect twice for the same injury. I arranged to take the depositions of the doctors in Seattle to show that the injuries were the same. I interviewed the Seattle radiologist there and compared his films with those taken in Los Angeles. When we put them in the shadow box side by side, we discovered that my expert had simply counted wrong. While he named the 5th lumbar vertebra, actually our man now had a compression fracture of the 4th lumbar at the juncture with the 3rd, instead of the 5th at the juncture with the 4th. The man had had an injury to the 5th lumbar for which he had received compensation but now he was suffering from an injury to the 4th, which my expert had miscounted when he made his report. I think he was entirely careful in so far as his profession was concerned. I assume that the treatment for a compression fracture of the 4th lumbar would have been exactly the same as for the 5th, and that the naming of the 4th so far as treatment was concerned made no difference, but it was extremely important from the legal point of view.

All of the foregoing has to do with your practices in connection with office routines and interpretations of x-rays with particular reference to the manner in which they may be interpreted from a legal aspect. It would be nice if the matter could end there. Most of you would probably prefer not to have to go to court or testify, but the probability of your escaping that onerous duty is very slight today. If, then, you are required to go to court, what should you do about it?

In the beginning, the attorney handling the case is going to want to have a conference with you. I don't know how most of you feel about such a conference, but members of my profession have observed some reluctance on the part of doctors to go over the case with them in advance. We have never been quite sure as to the source of this reluctance. It may be simply that the doctor feels he is too busy to waste time on a conference when all he expects to do is to testify to the truth. Or it may be that he feels the

attorney may want to color his testimony, which he would, of course, resent. Certainly that is not the purpose of a pre-trial conference between the attorney and the doctor, at least with an ethical attorney and an ethical doctor. The attorney realizes the doctor is busy, will respect his time, and will expect to pay for it. By the same token, the doctor should realize that the attorney may also be busy and that his time may also be worth something. It is earnestly suggested that you arrange for an appointment with the attorney and try to keep it, since the attorney cannot react in the same fashion as the patient who, upon being delayed in his appointment, left a note reading: "I have gone home to die of natural causes."

The attorney's purpose in having such a conference is twofold. First, he himself wants to know and is entitled to know what your testimony is going to be as a witness so that he may consider it within the entire framework of his case, and he needs to get from you the material upon which he can base appropriate questions. The second purpose is to apprise you of the issues in the case and the kind of questions you may have to meet on both direct and cross-examination so that you can prepare for them.

First and foremost, the attorney handling the case will understand the legal issues involved and you will understand the medical problems. I hope that you will not try to instruct the attorney as to the method of presenting the case, and by the same token I hope he will not try to instruct you on medicine. I can never forget the time that I walked into a doctor's office on a case in which I was interested as to the extent of injury only incidentally. My real defense rested on the theory that the man had been injured not on the railroad but in a hunting accident. As soon as we had shaken hands, the doctor said: "I have been over the case from top to bottom and in my opinion you should settle it." That made co-operation between lawyer and doctor difficult for a time.

The lawyer in the trial of the case is the advocate. He is expected to put his best foot forward for his client. The expert witness, whoever he may be, is presumed to be impartial and to give his opinions on the basis of his professional ability and without the advocacy of the case of either party. That is the attitude you should have and the impression you should give the jury. But in doing this, please do not lean over backwards. The best way I know of to avoid such a pitfall is the pre-trial conference with the attorney. It is very easy to fall into the same kind of a trap on cross-examination that you may have already fallen into in giving your report. That is to say, the use of the words "possible," "probable," "definite," and so on. In giving your testimony you should be as positive with respect to your opinion as I have suggested you should be in your written opinion. You will always meet with cross-examiner's questions that run about as follows: "While it may be your opinion, Doctor, that this x-ray shows no evidence of trauma, isn't it possible that the condition we see here might have been produced by trauma?" The doctor who falls into the trap by leaning over backwards to be fair, will simply say "yes," and thereby make his negative opinion positive. He should not argue with the cross-examiner, but he shouldn't stop with simply the word "yes." The reply should be "Yes, but all of the evidence in this case indicates to me that trauma was not involved."

Last but not least, assuming that the doctor has prepared himself by re-examining his films in advance of testifying and knows the issues after having been over the case with the attorney, he must continue to be careful in the courtroom. Never testify to the findings on any film presented in the courtroom until you have re-examined it and particularly noticed the date on which it was made. I trust you will never find yourself in the position of a certain physician who testified on direct examination as to the extent of an injury as shown by his pictures and

who on cross-examination was handed a film which appeared to be of the same portion of the anatomy and was requested to repeat his testimony concerning the injury. The doctor neglected to place the film in the shadow box, neglected to note the date on it, and neglected to examine it carefully. He testified again as to all of the conditions he had related in his direct examination. The cross-examiner let him tell the whole story without any effort to minimize it and then dismissed him from the stand, calling the jury's attention to the fact that the film thus glibly interpreted was taken before the date of the accident and showed no injuries whatever.

Nor was this doctor's predicament any more embarrassing than that of another eminent gentleman who fell for the use of the word "normal." You doctors tell me there is no such thing as a perfectly normal human anatomy, and that this is particularly true of the spinal column. By the same token, you see so many minor abnormalities that you pay little attention to them. In the case in question the claimant was not claiming bone involvement. Rather she was claiming a soft-tissue injury in the shoulder area. It was the idea of the plaintiff's doctor to appear to be very fair in admitting the lack of any bone involvement. On direct examination, this doctor stated there was nothing wrong with the claimant so far as the bone structure was concerned but that she had a soft-tissue injury. On cross-examination, films of the cervical region were placed in the shadow box and the doctor was asked: "Do we understand your testimony to be that this x-ray indicates, so far as bone structure is concerned, a perfectly normal condition?" The answer was "yes," though it so happened that the film did disclose a congenital rudimentary cervical rib. The doctor was asked whether or not such a cervical rib was normal. He was forced to admit that it was not and, while he protested vigorously that it had nothing to do with the alleged pain and disability of the patient, the jury was quite convinced that he was either a charlatan or incompetent.

No reputable attorney wants you to cover up any real injury or to enlarge on minor ones. He is entitled to your careful considered opinion, couched and supported in courageous positive language unqualified by weak-kneed speculation. If you can write your opinions and testify that way, you will be performing your true medicolegal function, the furtherance of the cause of justice.

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SUMARIO

Radiología Médico-Forense

Vistas las probabilidades cada vez mayores de que el radiólogo sea llamado como testigo pericial, sobre todo en casos en que figuren supuestas lesiones de la porción inferior del dorso, ofrécense aquí algunas indicaciones que sirvan de guía al mismo.

Los informes deben ser en términos concretos que no se presten a tergiversaciones. Hay que trazar una distinción neta entre los hallazgos roentgenológicos que puedan guardar relación con un traumatismo y los que no guarden dicha relación. En la radiografía misma deben aparecer la identificación (nombre) del enfermo y la fecha del examen. Hay que resguardarse contra inexactitudes en la interpretación, aunque carezcan de importancia médica, pues quizás posean valor legal. Una conferencia preliminar entre el abogado que gestiona el caso y el radiólogo será de la mayor utilidad para ambos.

En la sala de justicia, el testigo ofrecerá su opinión meditada en lenguaje firme y positivo, sin desvirtuarla con hipótesis endebles. Jamás debe dar testimonio acerca de los hallazgos en ninguna radiografía con que lo puedan confrontar sin estudiarla cuidadosamente y fijarse en la fecha de la misma.

Panel Discussion on Low Back Pain

Spondylolisthesis Without Isthmus Defect[1]

R. M. POTTER, M.D., and J. R. NORCROSS, M.D.

WITH THE development and widespread use of the moving grid in the 1920's, permitting satisfactory roentgenographic study of the lower spine, good understanding of congenital and acquired bone lesions in this area has become almost universal among roentgenologists, orthopedists, and industrial physicians interested in the low back. A great body of literature has developed concerning anomalies, residues of trauma, and degenerative disease of intervertebral disks and bone.

We have observed in increasing frequency in older age groups, but in many who have presented low back problems in industry, a lesion which we believe has not had sufficient recognition. This belief is based on the sparse attention given to the lesion in the standard textbooks and in the literature (1, 2) and on discussion with our colleagues interested in diagnostic roentgenology and orthopedics.

Spondylolisthesis, the term used to describe the extensive cases first observed by Kilian (3), may be translated literally as "falling of the vertebrae." He dealt with extreme cases of forward dislocation of the fifth lumbar vertebral body over the sacrum, resulting in a large palpable mass in the pelvis, partially blocking the pelvic inlet in obstetrical cases. Most of the common cases now seen in x-ray study show only limited displacement, and spondylolisthesis has come to mean forward (or backward) slipping of one or more vertebral bodies on the segment below.

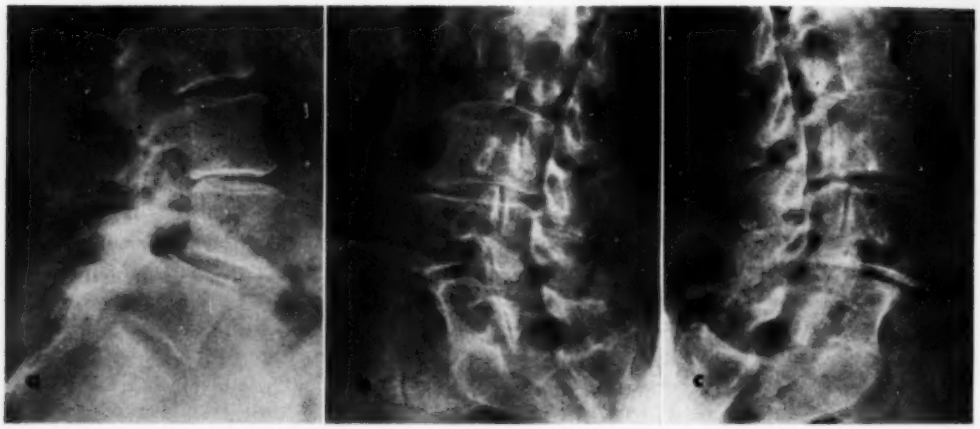

Fig. 1. a. Typical lateral roentgenogram of lumbar spine, showing forward displacement of fourth lumbar body on the fifth as a result of erosive changes of degenerative arthritis at facet joints. b and c. Right and left oblique projections showing intact isthmus on either side, the absolute reduction of joint space at facet joints, and extensive productive bone reaction.

Spondylolisthesis resulting from a defect in the isthmus or pars interarticularis has been recognized as a frequent and important structural lesion of the low spine. Spondylolisthesis also results, though less frequently, from anomalies of the articular processes and facets, fractures of the isthmus or articular processes, and destruction

[1] From the Departments of Radiology and Orthopedic Surgery, Northwestern Medical School, Chicago, Ill. Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13–18, 1953.

Fig. 2. Lateral projection through lumbar spine showing typical spondylolisthesis resulting from degenerative arthritic erosion of facets of the fourth lumbar vertebra.

of these parts by inflammatory or malignant disease.

In our experience, however, an increasing number of individuals have been seen with varying degrees of spondylolisthesis due to erosion of the facet joints in the lower spine by a degenerative arthritic process. The erosion of the cartilage and the subchondral bone in response to mechanical stress over the years is sufficient in some cases to permit forward displacement of certain lumbar bodies more than 1 cm. (Figs. 1 and 2). This process was apparently first described by Junghanns (2) in 1931 as "pseudospondylolisthesis." We prefer to describe the lesion as a form of spondylolisthesis, recognizing that forward (or backward) slipping can result from a variety of causes.

There are a few simple points of differentiation between spondylolisthesis resulting from isthmus defect and that due to degenerative arthritic erosion of the facet joints as demonstrated on lateral roentgenograms. When the lesions are clear cut and sharply defined, the interpretation is not difficult. Frequently secondary productive bone reaction may overlap the site of defect or erosive change and obscure the local lesion. Simple reference to the shifts of the bodies and spinous processes may facilitate the differentiation and permit accurate diagnosis (Fig. 3).

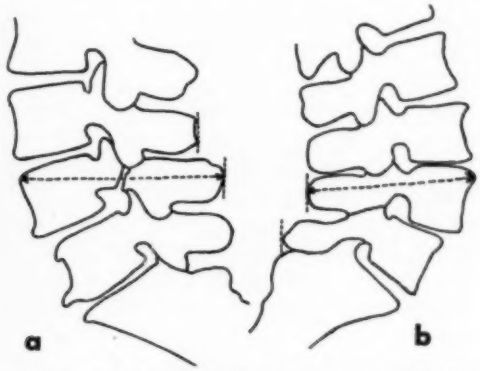

Fig. 3. Tracing of lateral roentgenograms of lumbar spine showing typical forward displacement of body of fourth lumbar on left (*a*) resulting from isthmus defect and on right (*b*), resulting from erosion of facets by degenerative arthritic process.

1. Both lesions show forward displacement of vertebral body.
2. In spondylolisthesis resulting from isthmus defect:
   (*a*) There is increase in the anteroposterior dimension of the vertebra.
   (*b*) The spinous process of the involved segment remains in normal relationship with segments below.
   (*c*) The spinous process of the vertebra one above the involved segment moves forward so that there may be palpable offset.
3. In spondylolisthesis resulting from degenerative arthritic erosion of facets:
   (*a*) The anteroposterior dimension of the vertebra is not increased.
   (*b*) The spinous process of the involved segment moves forward with the body. The spinous process of the segment below then becomes prominent and may be palpable.

If these points can be properly identified on the films, the differential diagnosis can be accurately made. One other thing may be mentioned. There is usually no evidence of erosion at the facets at the level of the involved segment in spondylolisthesis resulting from isthmus defect, because there is a separate ossicle comprising the spinous process and the inferior articular processes and it is not subjected to the same strains and wear as in the intact vertebral segment.

Spondylolisthesis from erosive disease of the facets occurs more commonly between the fourth and fifth lumbar segments, occasionally between the fifth lumbar and sacrum, and the third and fourth lumbar. Less frequently there is some involvement at two levels adjacent. We see an occasional case with involvement of the cervical spine, more often between the seventh cervical and the first thoracic segment. These are usually associated with exaggerated cervical lordosis in compensation for dorsal kyphos. Similarly the lumbar involvement appears to be more frequent with prominent lumbar lordotic curve. The lesion is seen more often in women than in men.

Pathologic studies by Junghanns (2) on Schmorl's collection of spines show that this lesion results from degenerative disease (arthritis deformans) with eroded surfaces of the facets. The roentgenogram shows features of degenerative arthritis with absolute reduction of joint space, thickening of subchondral bone, and marginal spurs. Occasionally there may be high-grade marginal proliferative spur reaction which simulates an irregular osseous tumor. Infrequently unilateral erosion may occur at one facet, permitting forward rotation of the involved side. If there is scoliosis, the erosive change at the facets is better developed along the concave side of the scoliotic curve, as is usual with degenerative arthritic involvement of a vertebral body.

The erosion of the facet joints and the marginal productive bone reaction frequently modify the form of the intravertebral foramen, with encroachment upon it, supplying a concrete anatomic reason for potential nerve root pressure.

In an attempt to give some picture of the incidence of spondylolisthesis resulting from facet erosion, we reviewed approximately 3,000 consecutive x-ray studies of the spine. This number includes all cases with films covering all or a part of the spine. Among these were 21 cases in which we made note of some forward displacement of one or more vertebrae resulting from erosion of facet joints by a degenerative arthritic process. Of the 21 cases, 2 were in the cervical spine and 19 in the lumbar spine. Of the 19 lesions in the lumbar spine, 3 were at the 3rd lumbar, 15 at the 4th lumbar, and 2 at the 5th lumbar (1 patient had both 4th and 5th lumbar lesions). Five patients were males and 16 females. These figures do not give a dependable measure of incidence, since the series is weighted with a large number of young males, but they do serve to indicate that the lesion, in some degree, is sufficiently frequent to demand explanation and evaluation.

COMMENT

In the interest of accurate diagnosis when spondylolisthesis is noted in film studies, the character of the lesion which permits the forward displacement of the body should be defined as accurately as possible. Using the simple criteria set down in this paper, the more common types, that resulting from defect of the isthmus or pars interarticularis and that resulting from degenerative arthritic erosion of the facets, can in most cases be differentiated. We believe that in some cases, where the lesions are obscured by productive bone reaction, improper diagnosis has been made in the past. Oblique views should not be necessary, in many cases of spondylolisthesis, for a precise differentiation, if the criteria set down are observed and one has films of good technical quality and examines them carefully.

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SUMARIO

Espondilolístesis sin Defecto del Istmo

La espondilolístesis debida a un defecto en el istmo o parte interarticular está reconocida como frecuente lesión orgánica de la porción inferior del raquis. Además, sin haber defecto del istmo, se ha observado espondilolístesis más o menos acentuada, a consecuencia de la erosión de las articulaciones de las facetas por un proceso de artritis degenerativa. La erosión del cartílago y del hueso subcondral en respuesta a tensiones mecánicas durante un período de años basta en algunos casos para permitir un desplazamiento de más de un centímetro hacia adelante de ciertos cuerpos de vértebras lumbares.

La espondilolístesis proveniente de la erosión por artritis degenerativa discrepa de la espondilitis debida a un defecto del istmo en dos sentidos: (1) no aumenta la dimensión anteroposterior de la vértebra; (2) la apófisis espinosa del segmento afectado se mueve hacia adelante con el cuerpo, proyectando entonces y volviéndose palpable la apófisis espinosa del segmento más abajo.

En muchos casos de espondilolístesis, no debe ser necesario tomar radiografías oblicuas para hacer una diferenciación precisa, si se observan las pautas expuestas y se cuenta con películas de buena calidad técnica que son objeto de estudio cuidadoso.

DISCUSSION

(Papers by Winston and Moreton; Moreton *et al.*; Ewing; Potter and Norcross)

James K. Stack, M.D. (Medical Director, Chicago & Northwestern R.R., Chicago): We have been interested in pre-employment x-ray examination of the spine on our railroad since 1935 and have continued with this practice except for the war years, when it had to be dropped because of the shortage of film. In a typical year, such as 1951, we review between 2,500 and 3,000 back films. If these films have been declared within normal limits by a consulting radiologist, then those men are passed; if there is any question in his mind about the relative normality of the film, I review the films in the light of the job for which the man has applied.

We do not take routine oblique films. First, expense probably plays a role, and secondly, as one gets into communities outside the large cities where expert technicians and expert interpreters of films are available, the oblique view isn't always adequate. We have found for our purposes that the anteroposterior and lateral and the tilted anteroposterior have been sufficient.

The percentage of rejections was in the beginning and still is strikingly high; it runs around 30 per cent. These people are rejected for congenital and acquired conditions. Our percentage of spondylolisthesis runs around 5 per cent, which agrees with the figures given by Dr. Moreton.

One of the peculiar things about the railroad business—and I am sure that Mr. Ewing will go along with this—is that a man is expected as a rule (the exceptions being the few who go from labor to management) to be doing the same things at the age of sixty—switching cars, machinist's work, maintenance of way—that he was doing at the age of twenty, and if you superimpose the acquired changes that are bound to occur in the back of a man who is doing heavy labor on a congenital condition, then you are in for real trouble. We don't get to see the people again who are rejected. However, if you have a judgment of $60,000 rendered against you—and it is paid—because a man who has a spondylolisthesis stoops over to pick up something, you can't help but wonder if your rejections for spondylolisthesis during the year may not perhaps have saved you money.

It is remarkable that none of these people have a pre-employment backache. As one reviews their histories taken prior to physical examination, he finds that they never before had any trouble with their backs in spite of the conditions for which they are rejected.

In the beginning, the motive of industry was not altruistic, but as time goes on it is becoming more so. We are taking the approach that a man who has something the matter with his pulmonary reserve

shouldn't be in one position and a man who has something the matter with his cardiac reserve shouldn't be in a certain job, and certainly a man shouldn't be asked to spend his life working hard on a railroad, or even permitted to do so, if he has any of the conditions that have been described in the preceding papers.

Arthur B. Smith, M.D. (Kansas City, Mo.): I should like to discuss the papers in the order in which they were presented.

I think that Dr. Winston's classification is a very excellent and a very usable one. I am sorry that he did not feel that he had time enough—or that it was applicable in the present paper—to mention specifically some of these abnormalities. He did mention a few of them and apparently they do produce some complaints.

Some of us are called upon, perhaps because we are not in a situation where the examining physician has the final word, to pass judgment on whether or not a defect seen is likely to cause symptoms. I think it is ideal when the radiologist can work with someone like Dr. Stack, who can examine these people and knows from personal experience what they will be called upon to do, who has seen the men work and can therefore evaluate the defect. He can take a great deal of the load off the radiologist, and I think he rightly should.

The only thing that I would like to have is a little more specific statement on the complaints in question and with what particular defects they are likely to be associated, though that would perhaps entail too long a discussion for this meeting.

I certainly like Dr. Moreton's description of spondylolisthesis, and I think the classification he uses is a very accurate one and one to which all of us could pay more attention. I only wonder whether, after going over these 4,000 cases, he found anything other than spondylolisthesis and isthmus defects to be worth mentioning. I know that the work he has done has taken a lot of time and that these are probably the most important of the various conditions observed. It would seem from his statement, however, that he had an incidence of 2.7 to 5.3 per cent of spondylolisthesis. Yet I believe Dr. Stack said they reject 30 per cent of their applicants. This would suggest that 25 per cent are rejected for other causes. I am sure that time will give us more to go on, but I wonder if all we are going to find is spondylolisthesis. If that were the main thing, it would undoubtedly make the examination of the low back much simpler.

The foregoing was my impression on first reading the paper, rather hurriedly. On a second reading I found that it was specifically stated that only spondylolisthesis and isthmus defects were being considered. I wonder if some others may not have got the impression that there isn't too much else of importance in the low back.

Mr. Ewing's paper I think was most excellent. It brings us up to date, it keeps us from getting sloppy and careless, and it emphasizes again that accurate and brief reporting is very important. The fundamental thing is that we've got to get off the fence. We can't take a middle stand on these things; we have to be on one side or the other and write an opinion that can't be misunderstood.

I was most interested in Dr. Potter's paper on the isthmus defects versus arthritic erosion of the facets. While the latter is apparently not too common, it does give us another cause of spondylolisthesis and one we are all going to have to look for. I recall hearing somewhere that there was a third cause—a possible congenital elongation of the isthmus which permitted a degree of spondylolisthesis without evidence of arthritic changes. Of course, traumatic defects are well known to all.

Robert D. Moreton, M.D. (Fort Worth, Texas): As we stated in the beginning of our paper, it was limited entirely to the incidence of spondylolisthesis and isthmus defects. We did not try to get into the subject of congenital anomalies such as sacralization and all that, because time did not permit and we felt that we would be only adding to the confusion.

The incidence of spondylolisthesis found in our whole group was 4.06 per cent, which I think was within the order of what Dr. Stack found and what we find in the literature.

John Norcross, M.D. (Chicago): I have enjoyed all these papers very much. There are a few points that I would like to emphasize, most of which have been already brought out.

In the first place, not only is the identification of films important but I would like also to urge the importance of their safekeeping. We all get tired of paying office rent for storage space for films not in the current file; nevertheless, some of these films may be invaluable five or ten years after they are taken. I know that some institutions, in order to get away from the cost of storing films, are transposing them to microfilm and then destroying the original film. Personally, I would much prefer to have the original film if there is any medicolegal question whatsoever.

The second point that I was very happy to see made by our first essayist was the plea for a large anteroposterior film on the original examination. Sometimes I think we are penny-wise and pound-foolish. We use too small a film for the spine to save the few cents that the film itself costs. I am sure all of you are aware of the fact that many times we could make the diagnosis on an original 14 × 17-inch scout film, and later cone down on the smaller film.

As to the routine view, I was surprised to hear Dr. Stack say that they are not taking obliques, partly because of the expense and partly because of

difficulty in technic. I feel that if a $60,000 judgment were going to be awarded, there again the oblique film would be well worth-while. It might be in contradiction to what Dr. Potter and I have done, but if you can identify a spondylolisthesis on a lateral film, and I believe you can, nevertheless a unilateral low-grade defect is very difficult to pick up on an anteroposterior film and of course will not be identified on a straight lateral. So I do think, if there is any medicolegal question at all, the oblique film should continue to be taken.

I enjoyed Mr. Ewing's remarks extremely. I am in a classification which he mentioned, a doctor who doesn't want to testify, but nevertheless I find myself very frequently in court. His remark about the pre-trial conference is most important both from a doctor's standpoint and from that of the attorney. There is nothing more embarrassing than to get on a witness stand and have the attorney ask a question that you would much prefer he would leave out. You can't tell what the cross-examiner is going to do, but you certainly should be prepared with your own attorney.

This same conference could be carried a little further, I believe, to include the radiologist, the orthopedist, and the attorney. If we understand each other all the way through, I think we can have a much better time when we do have to go to court.

Lastly, in some places in Chicago at least, the dictation of the report or interpretation of films is left to the resident in the resident training program. That is excellent training; there's no question about it. There is nothing like putting the diagnosis down in black and white.

On the other hand, this may prove to be very embarrassing when that record is brought to court. I suggest that the radiologist in charge can perhaps alleviate this situation if he will hold a conference with his residents who are writing the reports and interpreting the films, re-wording some of the statements so that the official record will carry the type of wording to which Mr. Ewing referred.

W. Edward Chamberlain, M.D. (Philadelphia): I believe it is of interest that in a study of 2,000 complete skeletons (disarticulated) in the Western Reserve collection, Todd found only 23 isthmus defects producing spondylolisthesis—an incidence only one-fourth of the lowest figure given by Dr. Moreton. I cannot explain this, but it suggests that perhaps the population is different in different parts of the United States.

I would like to ask Dr. Moreton if the lateral views were made with the patient erect. It has been very obvious to us that we find more displacement, and that it is easier to recognize separations of the neural arch, when the films are made in the erect position. Weight-bearing seems to make very apparent some defects that disappear or are very hard to show with the patient lying on the table.

The terminology "degenerative arthritis" worries me. The physician from time immemorial has made the mistake of ascribing certain findings to disease or calling certain findings abnormal. You remember how often we used to make a diagnosis of gastroptosis until somebody x-rayed normal people and showed that everyone's stomach is low. In the same way we might be making a mistake when we talk about the degenerative bone and joint changes that we see so frequently, especially in the older age group, because we have never done a very good job of x-raying a lot of asymptomatic human beings to determine the incidence of these conditions in the normal population, the people without low back complaints.

I have done a little of such work and, so far as I have been able to go, I have found that the incidence of these degenerative changes—I won't say degenerative arthritis because the pathologist does not find inflammation and the word "arthritis" to me indicates inflammation of the joint—to be the same among people with low back pain and those without a history of low back pain. I haven't found any correlation between these changes and the presence or absence of symptoms.

We have, however, found a correlation between these changes and the work histories of the individual. People who have not worked hard—who have avoided such activities as heavy lifting—are apt to have spines which do not manifest these hypertrophic ("degenerative") changes. And they are apt to carry such relatively normal x-ray appearances right on into ripe old age. Stevedores, on the other hand, and others who habitually place their bones and joints under heavy pressure, exhibit an extremely high incidence—close to 100 per cent—of what I would prefer to call "degenerative bone and joint changes." I wonder what Mr. Ewing would say to that.

At this moment I would like to add my word of appreciation and thanks to Mr. Ewing for his extremely instructive paper on the medicolegal aspects of this subject.

A final point. I think we ought to put into the record that negative x-rays should never be relied upon as a basis for classifying the plaintiff as a malingerer. There are many conditions that cause honest-to-goodness low back pain and plenty of symptoms that do not show on any kind of roentgenogram.

Francis Blonek, M.D. (Rock Island, Ill.): I would like to point out that one of the frequent causes of low back pain is an unstable lumbosacral angle. This condition, of course, can be demonstrated only by two lateral films of the lumbosacral region, one taken in a lateral decubitus and the other with the patient standing erect. This instability of the lumbosacral angle may be the reason for quite a severe low back pain with-

out other pathological changes in the bony structures of the lumbosacral region.

Mr. Ewing: I would like to answer the question as to whether or not these degenerative changes occur more frequently in persons doing heavy lifting and heavy work. I don't know how familiar you are with the railroad industry. I have never been an engineer or a fireman or a conductor or a brakeman myself, but I have been a truck driver and if I would compare the actual physical effort of trainmen, among whom we find most of these cases, with that of truck drivers, I'd say that the former have rather light work. There is little lifting involved. The engineer and fireman now ride in a Diesel locomotive with foam-rubber cushions. The conductor and the flagman ride in the caboose. I really don't think that I would term trainmen in railroad service engaged in truly heavy labor.

Roentgenologic Bone Changes Encountered in Frostbite, Korea 1950–51[1]

HAROLD A. VINSON, LT. COL., M.C., and RICHARD SCHATZKI, M.D.

THE STUDY OF frostbite usually is centered on the damage of soft tissues. Changes which might occur in the underlying bone have been mentioned sporadically in a number of publications, almost exclusively from continental Europe (2–5, 7–10). These publications have concerned themselves primarily with the description of the atrophy supposedly occurring in bone following cold injuries. Occasional instances of calcifying periostitis and rare joint changes are mentioned (2, 5, 7, 9). In a recent article, Edwards and Leeper (1) refer briefly to bone lesions. Systematic studies on the bone changes following frostbite in a large well controlled group have not been reported. The Korean war offered an opportunity to obtain such studies, and the results have been interesting, particularly as far as they pertain to late joint changes.

CLINICAL MATERIAL

This study is based upon observations on 100 enlisted men who incurred frostbite in Korea between Dec. 6, 1950, and March 5, 1951. The clinical findings in these patients are included in a report by Orr and Fainer (6). The importance of the racial background for the occurrence of the cold injuries has been stressed by these authors. Forty-one per cent of the series were Negro, which is considerably higher than the percentage of exposed Negro troops.

The majority of the patients had suffered severe cold injuries as indicated by the degree of soft-tissue damage. Orr's four degrees of frostbite were used for classification of the soft-tissue injury. The first degree consisted of erythema, edema, and superficial desquamation only. The second degree showed vesiculation of partial skin thickness. The third degree involved the full thickness of the skin, extending into varying depths of subcutaneous tissue with or without vesiculation. The fourth degree resulted in damage of the deep structures down to and usually including bone. Many patients had different degrees of involvement in different portions of the body at the same time. Classified according to the most severe degree, the totals show 3 patients with first-degree frostbite, 10 with second-degree, 70 with third-degree, and 17 with fourth-degree frostbite.

Sixty-four patients had clinical involvement confined to a portion or all of both feet; in 2 involvement was confined to both hands. In 25 a single foot was involved, and in 1 only one hand. The remaining 8 had various combinations of frostbite of the hands and feet. The overall total showed clinical frostbite of a portion, or all, of the following areas: 80 per cent, right foot; 86 per cent, left foot; 7 per cent, right hand; 8 per cent, left hand.

Where there was a marked difference between the appearance of one digit and the remainder of the hand or foot, the distribution was as follows:

Right Foot	Left Foot	Right Hand	Left Hand
1st toe.. 36	1st toe..38	Thumb. 1	8
2d toe... 8	2d toe... 6	Index finger. 1	
3d toe... 0	3d toe... 1	Middle finger. 2	(Not classified as to digits)
4th toe.. 0	4th toe.. 1	Ring finger. 2	
5th toe.. 2	5th toe.. 6	Little finger. 1	
Heel.... 1	Heel.... 3		

ROENTGEN EXAMINATIONS AND FINDINGS

The majority of the 100 patients on whom the study is based had early roentgen studies. The shortest interval between exposure and x-ray examination was nine days, the longest one hundred and ten days. Repeated examinations were made

[1] From the Army Medical Research Laboratory, Fort Knox, Ky. Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Dec. 13–18, 1953.

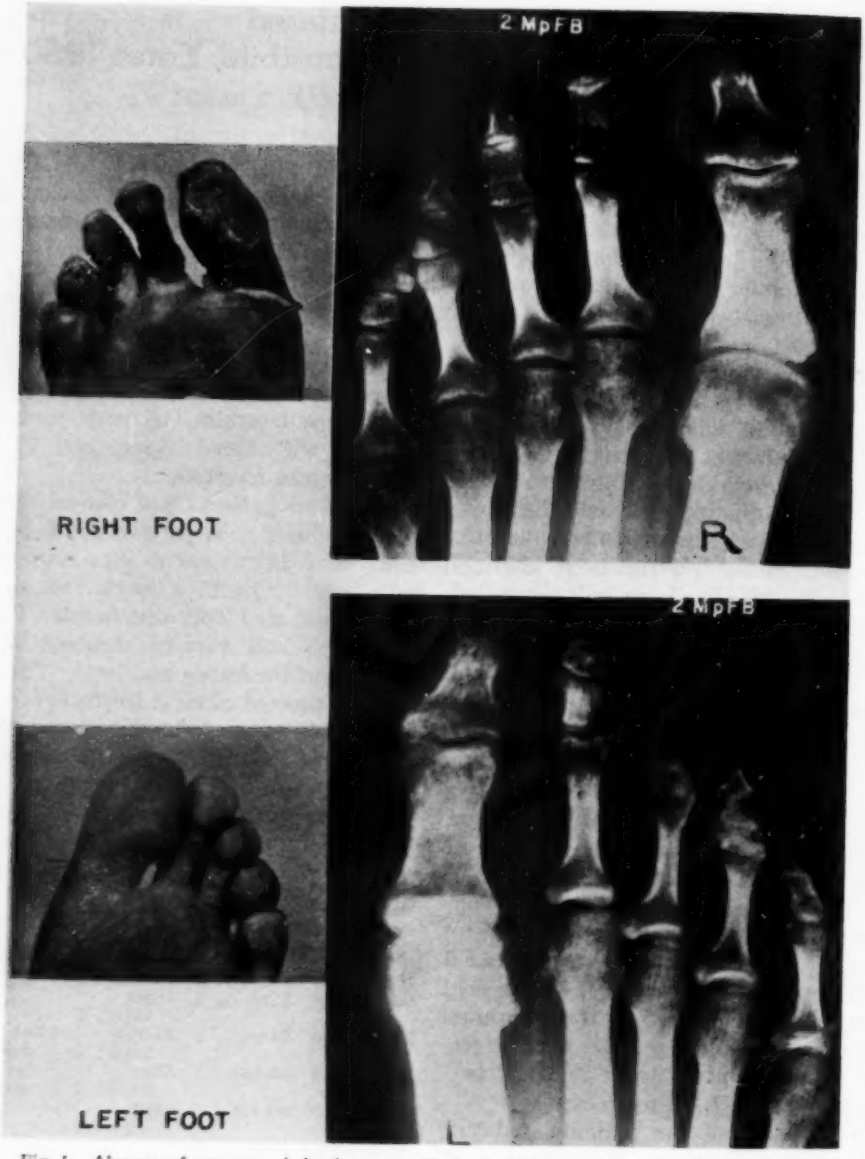

Fig. 1. Absence of osteoporosis in the mummified toes of the right foot. Note osteoporosis of the toes of the left foot, particularly the great toe, and also of the metatarsals and the bases of the second to fifth proximal phalanges of the right foot. The photographs of the feet and the roentgenograms were taken on approximately the same date, two months following the frostbite. *Clinically:* Fourth-degree frostbite of toes of right foot.

thereafter, for an average of more than three later examinations. The number of those examined radiologically naturally decreased as time went on, but of the original 100 patients, 62 were examined eight months post-frostbite, 47 one year post-frostbite, and 38 fifteen months post-frostbite.

In 36 patients no bone abnormality was found at any time. This group included a number of cases with marked mummification of the soft tissues. The absence of

roentgen changes in the presence of mummification has been stressed by many authors. It is easily explained by the absence of metabolic changes in the bone, which is severed from its blood supply (Fig. 1).

Sixty-four patients showed some alterations in the roentgenologic appearance of the bones at some time. The roentgenologic changes were classified into four groups, as follows:

Group A. Osteoporosis.
Group B. Acromutilation (mutilation of terminal phalanges due to exposed bone).
Group C. Late changes in the bones close to the joints of feet or hands.
Group D. Other bone changes.

Group A: Osteoporosis: Osteoporosis, although noticeable in 58 of those exposed, was not marked except in 1 case (Fig. 2). When it occurred, it was usually present in the fourth to the tenth week. The evaluation of slight degrees of osteoporosis is extremely difficult under the best technical circumstances and even more so in a series such as this, where the examinations were performed in different x-ray departments. It is of interest, however, to note the extreme rarity of a severe degree of osteoporosis during any stage of this observation period and its complete absence after six months following injury. This is in contradistinction to various statements in the literature (Oehlecker, 5; Ruckensteiner, 7).

Group B: Acromutilation (Bone Changes Following Exposure to Air): This group included 9 patients. Almost all the lesions involved the big toes. The second toe was involved in 2 instances and the heel in 1.

When studying late films of patients following frostbite, one at times sees mutilation of the tips of the extremities, particularly involving the tufts of the great toes. The literature attributes these deformities directly to exposure to cold. An analysis of the cases in this study shows that in most instances the overlying soft tissue had been damaged to such a degree that the bone had become exposed to air and either had been destroyed by osteo-

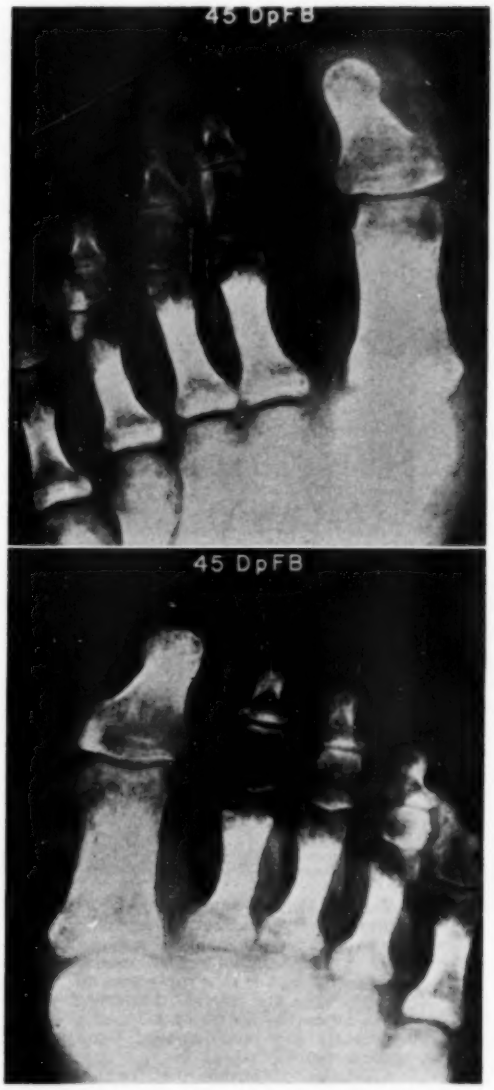

Fig. 2. Bilateral osteoporosis. This was the only case in the series showing a fairly marked degree of osteoporosis. Films were taken forty-five days post-frostbite. The earliest changes were seen twenty-four days post-frostbite. Some osteoporosis was still demonstable on films taken four months post-frostbite. Films taken at eight months showed no abnormality of the bones.
Clinically: Third-degree frostbite of both feet, involving particularly the great toe.

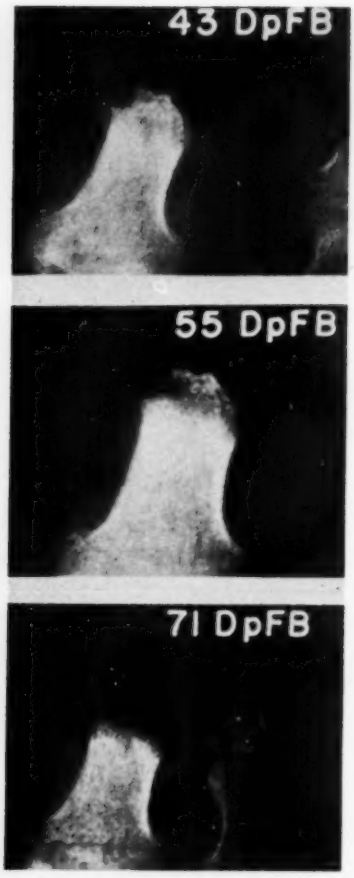

Fig. 3. Mutilation of the tip of the right great toe. Roentgenograms taken forty-three, fifty-five, and seventy-one days post-frostbite. The earliest roentgenogram shows a soft-tissue defect reaching the bone; the second shows formation of a sequestrum, which apparently had been removed before the last film was taken.

Clinically: Third-degree frostbite with ulceration of the tip of the great toe and visible exposure of bone.

myelitis or had been subsequently removed surgically (Fig. 3). Actual exposed bone could be seen in most instances on the films. In the other cases, ulceration of the soft tissues, visible on photographs, made exposure of the underlying bone appear likely, even though actual surgical removal of a sequestrum was not always mentioned in the record. Not a single case was seen in which direct influence of

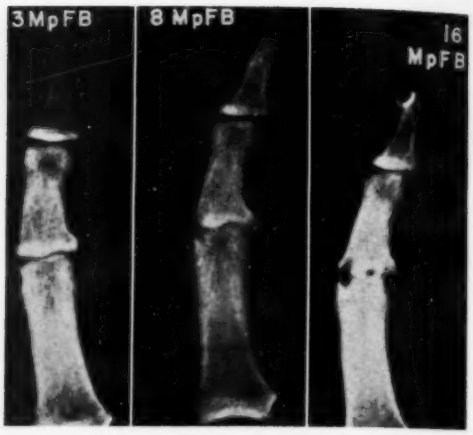

Fig. 4. Development of late bone changes in left fifth finger. No abnormality is seen three months post-frostbite. Definite changes are evident eight months post-frostbite, and these had increased considerably at sixteen months. The patient had lost his gloves while under enemy fire and his ungloved hands were exposed to the cold for nine hours. Third degree frostbite of both hands developed. The proximal phalanges of the left hand revealed a bullous cuff. The right hand showed similar changes, though less marked.

Roentgenologically there were additional late changes involving the second and fourth fingers of the left and the fifth finger of the right hand, not as marked as those seen in the illustrated left fifth finger.

the cold on bone under intact skin could be pointed to as the cause of the mutilation of the phalangeal tips.

Group C: Late Changes Close to Joints of Hands and Feet (Figs. 4–9): This group proved to be of particular interest. The lesions consisted of small, usually round, punched-out areas of decreased density which later were frequently surrounded by a margin of dense bone. The defects in most instances opened into the joint space. Usually, although not always, they were present near the edge of the joint, approximately in the area of the attachment of the capsule. In a few instances, the defects appeared to be separated by a narrow band of normal bone from the joint surface. It is possible that a different view might have shown a direct opening of the apparently subarticular defect into the joint space. Narrowing of the joint space occurred in only a few markedly affected joints.

Juxta-articular bone changes were found in 7 soldiers. The hands were involved in

only 2 of these. One of the 2 also had involvement of joints of the feet, the other did not. A single foot was involved in 3 cases, while in 3 there were changes in both feet. A total of 25 joints were affected in the 7 soldiers. They included 9 proximal and 7 distal interphalangeal joints of the toes, as well as 3 metatarsophalangeal joints. The hands showed involvement of 4 proximal and 2 distal interphalangeal joints. The toe most commonly affected was the fifth (8 joints in 6 fifth toes). The joints of the great toe which clinically showed an overwhelming preponderance of frostbite injury were involved in only 5 instances. This discrepancy is striking.

An attempt to correlate the joint changes with the clinical manifestations of frostbite showed that the involved joint always belonged to a toe or finger which originally had shown clinical evidence of frostbite injury. Quite frequently, however, the digit with the most marked initial soft-tissue damage showed no joint change, while digits with less soft-tissue damage in the same patient did so. Third-degree frostbite was present in only 5 of the involved digits; in others the frostbite was of second or first degree. It is interesting to note that Orr and Fainer saw a late disturbance of sweat (hyperhidrosis), in both feet when only one foot had originally shown clinical evidence of frostbite. This would indicate that cold can produce tissue alterations without gross evidence initially of even a first-degree frostbite.

The joint changes did not become noticeable until several months after cold exposure. With the exception of 1 case in which minor changes were first seen three months post-frostbite and another in which they were seen five months post-frostbite, none of the joint changes were discovered until eight months post-frostbite. Since,

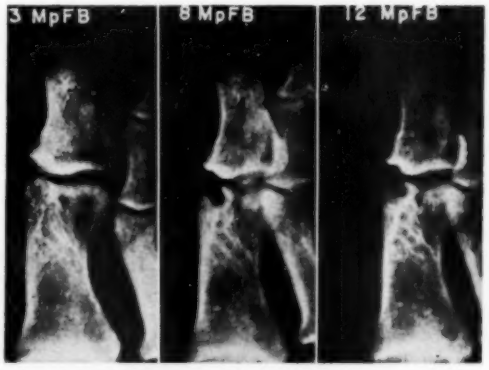

Fig. 5. Development of late joint changes in right first toe.

Questionable small defect is seen three months post-frostbite. Definite defects are present eight months post-frostbite, and these had increased four months later. The fourth and fifth toes of the same foot showed similar joint changes (see Fig. 6). Third-degree frostbite of the toe illustrated.

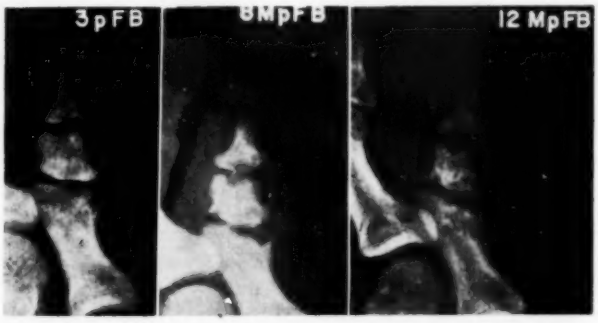

Fig. 6. Development of late joint changes involving both interphalangeal joints of the right fifth toe (same patient as Fig. 5). No changes are seen three months post-frostbite. Definite changes are established eight months post-frostbite. There is only slight increase of the deformity four months later.

Clinically: First-degree frostbite of right fifth toe. At the time of last examination, twelve months post-frostbite, there was restriction of motion in the involved joints of this toe. No pain.

with the 2 exceptions mentioned, roentgenologic changes were not noticed before the eighth month, it seems worth while to point out that, of the original 100 soldiers, only 62 were re-examined at so late a date. The 7 soldiers showing these particular bone changes represent 11.3 per cent of the total series of 62.

In most of the cases, there was a gap in the roentgen observations between the third and eighth month. It is likely that the majority of the joint lesions would have been visible some time between the third and eighth month if roentgenologic examinations had been done during this interval.

No joint normal at the eighth month examination showed later evidence of pathology, at least not in the relatively short observation period. There was, however, a definite increase in the degree of joint involvement between the eighth and and the twelfth month in some cases. Observations beyond the twelfth month are incomplete. When done, a fifteenth-month examination showed no further change in most instances, although in one joint there was a slight progress of the lesion. Later observations in this group

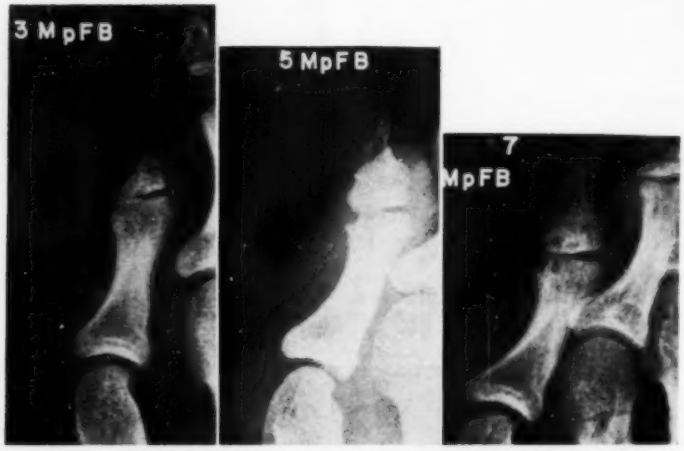

Fig. 7. Late development of joint changes in left fifth toe. No abnormality three months post-frostbite. Definite defect five months post-frostbite with considerable increase of the deformity at seven months.
Clinically: Third-degree frostbite.

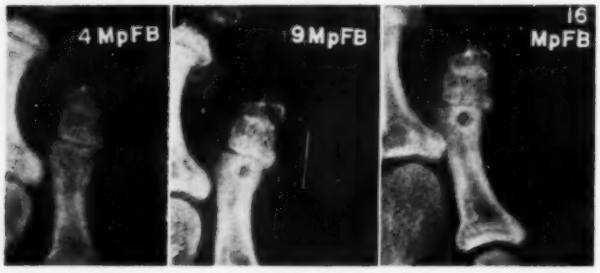

Fig. 8. Development of late juxta-articular bone changes of right fifth toe. No abnormality four months post-frostbite. Round defect with surrounding bone reaction nine months post-frostbite with no change seven months later. Although no connection with the joint is visible on these films, it is possible that a different projection might have shown such a connection.
Clinically: First-degree frostbite of the left foot, including this toe.

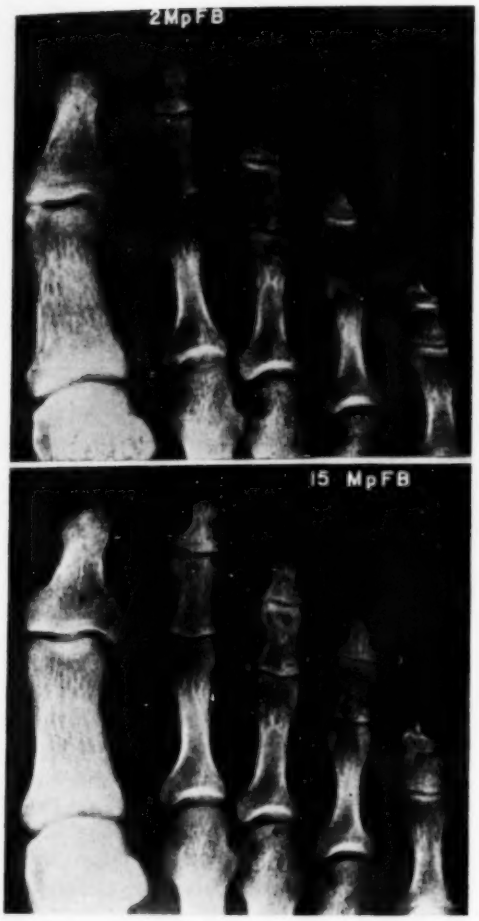

Fig. 9. Development of late juxta-articular bone changes in second, third, and fifth toes of right foot. A roentgenogram two months post-frostbite shows osteoporosis but no joint changes. A roentgenogram fifteen months post-frostbite shows sharply defined defects in three toes. Some of them are definitely connected with the joint surface. The others might be shown to be in a different projection.

Clinically: First-degree frostbite of the greater portion of the right foot; blister formation only over the distal phalanx of the third toe.

are obviously desirable and will be attempted.

For the sake of completeness, it should be mentioned that in a few instances small juxta-articular defects which simulated the above bone changes were seen on early films. They were considered as having existed prior to frostbite, since they had dense margins and did not change during further observation.

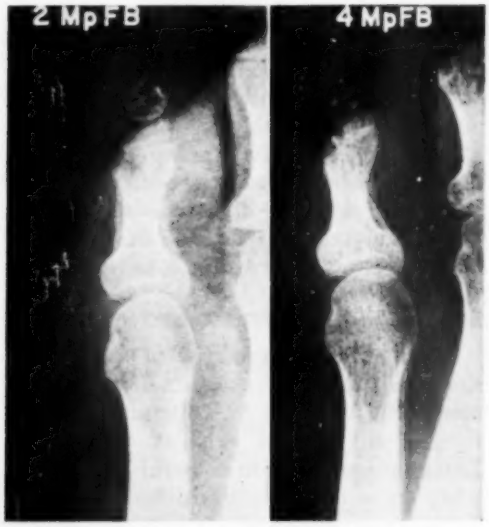

Fig. 10. Periosteal new bone formation of the left fifth metatarsal and proximal phalanx two months and four months post-frostbite. There is suggestive evidence of osteomyelitis in the head of the proximal phalanx at two months, which is no longer visible at four months. The terminal phalanx apparently was partially mummified and was removed in part before the four-month roentgenogram was obtained.

Clinically. Third-degree frostbite of the left fifth toe extending into extensive bulla over the lateral aspect of the foot.

Of the 7 soldiers with joint changes post-frostbite, 5 were Negroes and 2 were white.

The absence of late clinical symptoms referable to the involved joints was striking in most instances. In only 1 case (Fig. 6) was there any restriction of motion of the joint.

Group D: Other Bone Changes: This group comprises 4 cases which could not be readily classified otherwise. Two of the men in this group had periostitis. In 1 of them, a 5th metatarsal and the corresponding proximal phalanx showed periosteal new bone formation (Fig. 10). In the head of the phalanx there was suggestive evidence of osteomyelitis. Clinically third-degree frostbite was present. The other patient showed periosteal new bone formation of the proximal phalanx of the 4th toe and of the 5th metatarsal bone. Third degree frostbite involved all toes.

A third case showed early disintegration of the middle phalanx of the fifth toe in an area of mummification. This may have

been osteomyelitis, but definite proof is lacking. Finally, the fourth member of the group has a defect in the terminal tuft of a second toe without evidence of exposure of the bone to air. He did have an ulcer over the involved area. On none of the films available was the bone seen to reach the surface. For that reason, the case could not be classified in Group B, although it probably belongs there.

DISCUSSION

The roentgen examination of the skeleton shows no demonstrable abnormality immediately following frostbite and is therefore of no clinical help at that stage. Later, however, bone changes may occur. They are at times of clinical significance.

The most common abnormality in the bone is the presence of osteoporosis. In contradistinction to reports in the literature, the osteoporosis in these cases as seen in our series was not severe. It was of short duration and offered no clinical problem. On the other hand the presence or absence of osteoporosis may at times be useful as an indicator of the vitality of the underlying bone. The bone which shows evidence of osteoporosis obviously is viable, with preserved vascularization and metabolism, while absence of phalangeal osteoporosis in the presence of osteoporosis of metatarsal and tarsal bones is suggestive of absence of circulation in the involved phalanges.

Periosteal new bone formation was observed in a few instances. Oehlecker (5) has pointed out that this new bone formation occurs particularly in a phalanx just proximal to an area of marked mummification. In our cases it was seen in 2 instances just proximal to the area of maximal cold injury. Like osteoporosis, periostitis is an indicator of viability. Its demonstration may therefore be of clinical significance in a borderline case.

Of particular interest are the bone changes which were noted close to the joint surfaces in 7 cases (Group C). As stated before, these changes did not become noticeable until several months after the cold injury. At times they involved joints with only minimal initial overlying soft-tissue damage. We have been able to find only a few similar published cases, none in the American literature. Loehr (2), von Tempsky (9) and Oehlecker each describe a case. In all 3 the frostbite involved the hands. Ruckensteiner states that he has seen similar changes in the feet of skiers, but publishes no clinical details and no roentgenograms. The joint changes in the 3 documented cases from the literature were observed between six months and four years following frostbite. Limitation of motion of the involved joints was present in all 3 cases. In Loehr's case there was also transient swelling of the joints, and in von Tempsky's case pain on motion. The involved joints in our own cases appeared normal to clinical observation, with the exception of the joints of the fifth toe in 1 instance (Fig. 6), which showed limitation of motion. This difference from the observations of the previous authors is probably primarily due to the fact that their cases involved hands, and in the present cases the feet were predominantly affected. It is also possible that the observation period in our cases is still too short and that some clinical symptoms will appear later.

The etiology of these juxta-articular bone changes is obscure. Direct influence of the cold on the bones appears to be excluded by the fact that the overlying soft tissues showed in some instances very little evidence of frostbite. It is very tempting to postulate vascular changes, either anatomical or functional, as the cause for the late bone changes. Radiologically, the lesions are similar to those seen frequently in rheumatoid and occasionally in degenerative arthritis of the hands and feet. Injury to the joint cartilage may be the common denominator in all three conditions. Pathological and experimental studies are obviously needed in the further investigation of this problem. Its solution may not be without significance for the basic problem of cold injury.

SUMMARY

1. The early and late (up to fifteen months) bone changes occurring in a carefully observed group of 100 soldiers with frostbite are described.

2. In 36 cases no bone abnormalities were found at any time. This group includes most cases with mummification of toes.

3. Osteoporosis was seen in 58 instances. It was always transient and usually not severe. Osteoporosis, if present, is evidence of a viable bone.

4. Acromutilation (mutilation of terminal portions of bone, usually terminal phalanges) occurred in 10 instances. It could be traced to loss of overlying tissues, exposure to air, and usually subsequent surgical removal of the exposed fragment.

5. Late bone changes close to joints of hands and feet are of particular interest. They occurred in 7 soldiers out of a group of 62 which had at least an eight months observation period. The changes consisted in sharply defined, punched out defects usually at the joint edge. With 2 exceptions the changes were not noticed until eight months post-frostbite. The lesions frequently increased in size during the first year post-frostbite but no new lesions were seen after the eight months examination.

There was no correlation between the degree of the soft-tissue injury and the joint changes. In some instances the involved digits had shown clinically only first-degree frostbite.

With one exception the involved joints showed no late clinical abnormality.

6. The arthritic changes are of theoretical interest. Their further study may throw some light on the etiology of frost injury in general.

7. Frostbite is an additional etiological factor in the type of arthritis presenting small subarticular punched-out areas in the bone close to the joint.

NOTE: The authors wish to thank Lt. Col. K. D. Orr for his great help in the preparation of this paper.

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SUMARIO

Alteraciones Oseas Observadas Roentgenológicamente en la Congelación. Corea 1950-51

Descríbense las alteraciones óseas incipientes y tardías (hasta quince meses) aparecidas en una serie cuidadosamente observada de 100 soldados con congelación que afectaba los pies y las manos. En 36 casos, no se descubrieron anomalías óseas en ninguna ocasión. Este grupo comprende la mayoría de los que mostraban momificación de los dedos de los pies.

Había osteoporosis en 58 casos, pero fué siempre pasajera y por lo general no fué grave. Su presencia es importante como indicación de la viabilidad de los huesos.

En 10 enfermos, observóse acromutilación (mutilación de las porciones terminales del hueso, habitualmente las falanges terminales), pudiendo relacionarse con la pérdida de los tejidos sobreyacentes, exposi-

ción del hueso al aire y por lo general con la subsiguiente extirpación quirúrgica del fragmento expuesto.

Hubo alteraciones óseas tardías cerca de las articulaciones en 7 soldados de un grupo de 62, que fué observado durante un período a lo menos de ocho meses. Esas alteraciones consistieron en brechas excavadas, netamente definidas, casi siempre en el borde de la articulación. Con 2 excepciones, no se notaron las alteraciones hasta a los ocho meses de la congelación. Las lesiones aumentaron frecuentemente de tamaño durante el primer año consecutivo a la congelación, pero no se observaron otras nuevas a partir del octavo mes. No hubo correlación entre esas alteraciones óseas y la gravedad de la lesión de los tejidos blandos. Con una sola excepción, las articulaciones afectadas no revelaron anomalía clínica tardía. Radiológicamente, esas lesiones yuxtaarticulares eran semejantes a las observadas frecuentemente en la artritis reumatoidea, y a veces en la degenerativa, de las manos y los pies, sugiriéndose que una lesión del cartílago articular tal vez sea un factor común a los tres estados morbosos.

DISCUSSION

L. Henry Garland, M.D. (San Francisco): When your president was kind enough to invite me to discuss this interesting paper, I assumed that it was because he knew of my long standing interest in skiing. However, it may have been because he wanted "the cold eye from California" to stimulate a gentle debate, or because he thought our current relations with Russia make frostbite a topic of continued general interest, as indeed it is.

The authors have classified the soft-tissue changes in their cases according to Orr's four degrees of frostbite. We understand from the work of Meryman[1] and others that apparent freezing or non-freezing of the tissues at the time of injury would be a preferable basis. In experimental studies, freezing tissue has been shown to produce massive cellular dislocation with irreversible, non-specific cell damage. On the other hand, cold injury without freezing introduces selective, cumulative damage, primarily through anoxia.

The authors base many of their conclusions on the presence or absence of *osteoporosis* and wisely state that the evaluation of lesser degrees of that condition is extremely difficult. In addition, it is to be noted that many of their patients were immobilized for days or weeks and therefore were subject to complicating disuse osteoporosis.

It is my impression from reading their manuscript that the so-called acromutilations or auto-amputations were due primarily to infection and not freezing; all were associated with exposure of bone and therefore potential infection.

The *clinically silent juxta-articular decalcifications* noted several months after exposure to cold are of interest. Most if not all of these are non-specific, and it seems to me very questionable whether they can be attributed to the frostbite. This point remains to be validated, and histologic studies will doubtless be essential before a conclusion can be reached.

It has been my privilege to see a group of cases of severe frostbite injury in troops returning from Korea *via* Letterman Army Hospital. Arteriograms were obtained in one of these cases. The patient was admitted with severe damage to the soft tissues of the foot. In the preliminary film there was no gross evidence of osteoporosis. The arteriograms show that the blood supply of the ankle and foot has been cut off, and that a collateral circulation has developed about 2 cm. proximal to the ankle joint. If Colonel Lodmell happens to be in the audience, I would like to suggest that he can add a great deal to the usefulness of arteriography by the study of some of these cases. It aided the surgeons at Letterman Hospital to make more selective amputations, sometimes with less loss of substance to the patient.

Richard Schatzki, M.D. (Belmont, Mass.): It was a very nice opportunity for me when I was asked by the Surgeon General's office to review these cases with Colonel Vinson. I was happy to have the opportunity to see such a large number of well followed-up cases. We went at the study completely unbiased, as we knew nothing about roentgenologic changes in frostbite before we started. A system of changes became obvious after we had studied the films for some time, and this led to the purely practical classification which Colonel Vinson has presented.

As far as osteoporosis is concerned, we did not intend to make it appear an important problem. It did not seem to be—either clinically or roentgenologically. We thought that the osteoporosis was due to immobilization, but Colonel Orr, who saw these patients during their early hospitalization, assures us that they were not immobilized.

[1] Meryman, H. T.: The Mechanism of Local Cold Injury. Naval Medical Research Institute Reports NMOOO o18.01.07, 1953.

Possibly transient hyperemia plays a role in this temporary osteoporosis.

In regard to Dr. Garland's question as to whether the juxta-articular changes might have preexisted: they did not, at least as far as the radiologic evidence goes. The first films in all the cases which were shown appeared normal; the changes did not appear until months later. It is hard to believe that joint changes occurring in such a high percentage in these young soldiers following frostbite were purely coincidental and not connected with the exposure to cold.

I regret very much that we do not have histologic studies, but these patients had no reason to sacrifice their phalanges. At the present time, studies on rabbits are on their way under the direction of Colonel Blair. They may give some histologic evidence.

Venous Aneurysms of the Mediastinum[1]

TED F. LEIGH, M.D., OSLER A. ABBOTT, M.D., JAMES V. ROGERS, JR., M.D., and BRIT B. GAY, JR., M.D.

THIS COMMUNICATION is concerned with aneurysms arising in venous structures in the mediastinum. In 2 of the 4 cases to be reported the aneurysm was in the superior vena cava, in 1 in the hemiazygos vein, and in 1 in the azygos vein.

The term "aneurysm" is derived from the Greek and signifies a "widening." In common usage it is generally applied to an arterial lesion, but according to definition (1) it may be used in reference to a vein as well. We prefer it to "varicosity," which is commonly used for dilatations of the veins.

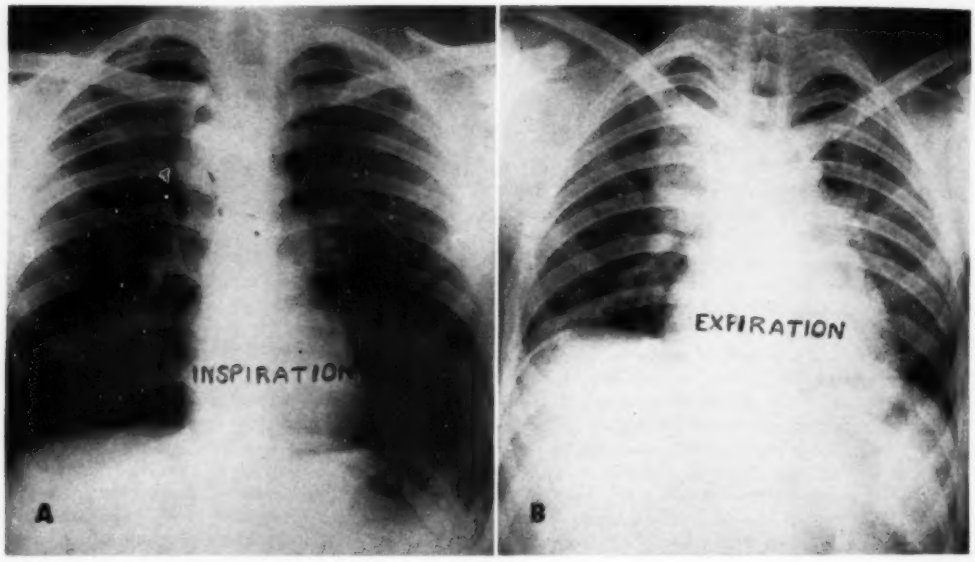

Fig. 1. Case I. Inspiration (A) and expiration (B) roentgenograms of the chest, showing the pliability of the superior vena caval aneurysm. Wide pulsations were observed fluoroscopically.

ANEURYSMS OF SUPERIOR VENA CAVA

The first case to be described is one of aneurysm of the superior vena cava, probably congenital in origin. At the time of its original publication in 1950 (2), a review of the literature revealed no similar example, nor has any been found since that time.

The etiologic agent producing mediastinal widening frequently presents problems in identification. With certain types of widening, the possibility of venous aneurysm should always enter into the differential diagnosis, as will be shown.

CASE I: *Congenital Aneurysm of the Superior Vena Cava.* A 19-year-old white male college student was found, on a roentgenologic survey (70-mm. film) in June 1947, to have a tumefactive lesion in the superior mediastinum, on the right side. He was in excellent health and had no symptoms referable to the chest. The past history, physical findings, and laboratory studies were essentially normal.

Routine roentgenograms showed the mediastinal mass to be adjacent to the trachea, but not compressing or displacing it; its lateral border against the

[1] From the Departments of Radiology and Surgery, Emory University School of Medicine, Emory University, Ga. Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13–18, 1953.

right lung was sharply defined, but its medial border within the mediastinum could not be identified. There was considerable change in the shape of the mass with respiration; it diminished in size on inspiration, and expanded with expiration (Fig. 1). Similar alterations were noted when the patient changed from an upright to a horizontal position. Fluoroscopically, pulsations of wide amplitude were observed, particularly following forced expiration. It could not be determined whether these pulsations were intrinsic or transmitted. They were paradoxical to those of the aorta.

Angiocardiography with 70 per cent Diodrast showed the lesion to be a fusiform dilatation of the superior vena cava, measuring on the films 5 cm. in its greatest diameter (Fig. 2). The vein narrowed down to normal size just before its entry into the heart.

In July 1948, a right thoracotomy was performed. The lesion was identified in the right mediastinum. It proved to be a large aneurysm of the superior vena cava, thin-walled and bluish in color, with multiple small grape-like dilatations on its anterolateral surface just proximal to the heart. Several similar dilatations were present in the major azygos vein, a short distance proximal to its insertion into the vena cava. Both the left innominate and the right internal mammary vein entered the aneurysm. Wrapping of the thin-walled structure with reactive-type cellophane (polythene with diacetyl phosphate) was done in order to promote the proliferation of fibrous tissue and thus strengthen the wall of the vessel.

The postoperative course was uneventful. One month later, there was little change in the size of the superior vena cava as seen fluoroscopically, but its pulsations were definitely decreased. In January 1949, a repeat angiocardiogram showed moderate diminution in the diameter of the aneurysm and a mild constriction at its distal end.

At the present time the patient is in excellent health.

The final diagnosis was aneurysm of the superior vena cava, probably congenital in origin.

From a roentgenologic standpoint, the most striking features in this case were the pliability of the lesion, allowing marked changes in shape with respiration and with positioning of the patient, and the wide excursions with pulsations. These findings were suggestive of a fluid-filled structure, but the true nature of the lesion was not apparent until the angiocardiograms were made.

This aneurysm, unlike that in the following case, was uncomplicated by other congenital lesions so far as could be determined roentgenologically and at surgery.

Fig. 2. Case I. Angiocardiogram at the moment of opacification of the lesion. The contrast substance is well concentrated in the fusiform aneurysm. Compare with Fig. 4.

The second case is one of a large aneurysm of the superior vena cava, resulting from an abnormal insertion of all of the pulmonary veins into tributaries of the right atrium, with an associated interatrial septal defect.

CASE II: *Aneurysm of the Superior Vena Cava Resulting from an Anomaly of the Pulmonary Venous Return; Interatrial Septal Defect:* The patient was a white female who at ten months of age was found to have a persistent tachycardia of 180. A three-day trial of digitalis did not slow the heart appreciably. The mother stated that the child had developed normally in every way, and that she began to walk at eleven months of age. Frequently she choked on liquids, but had no trouble in swallowing solids. No cyanosis had been observed.

The child's pulse was 116, blood pressure 90/65, respirations 24. The heart was moderately enlarged, but no murmurs were heard; the rate was regular and rhythmical.

Roentgenograms revealed bilateral widening of the mediastinum, more to the right than to the left (Fig. 3). Fluoroscopically, no changes were noted in the size or shape of the lesions with respiration. There was a mild degree of atelectasis in the anterior division of the upper lobe of the right lung.

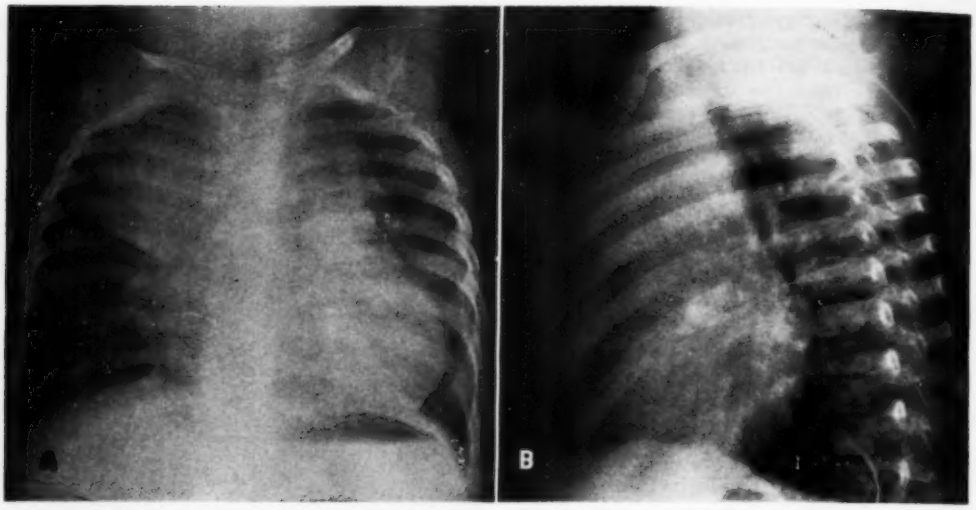

Fig. 3. Case II. Anteroposterior (A) and left lateral (B) roentgenograms of the chest. The mediastinum is widened bilaterally. There is atelectasis in the anterior division of the right upper lobe. The heart is enlarged.

Fig. 4. Case II. Angiocardiogram. Initial film of series, with the vena caval aneurysm and the right auricle containing diluted contrast substance. The anomalous collecting vein was not sufficiently opacified for visualization on any of the films of this series.

No significant tracheal or esophageal deviation was observed. The enlargement of the heart was thought to be entirely right-sided.

Angiocardiographic examination revealed a large aneurysm of the superior vena cava (Fig. 4). The contrast medium was well concentrated within the shoulder and neck veins, but showed considerable dilution on entering the lesion, and within the chambers of the right heart, indicating an admixture of large quantities of blood within the aneurysm. The right auricle and ventricle were moderately enlarged. There was no visible opacification of the left auricle or left ventricle on any of the films of the series, nor was any anomaly of the pulmonary veins visible.

Several months later, repeat roentgenograms showed an apparent increase in the size of the aneurysm, and the patient was experiencing some respiratory difficulty. On the basis of these later findings, and in view of the possibility that the lesion might be a congenital aneurysm of the vena cava, exploratory thoracotomy seemed advisable.

On opening the right chest, the large aneurysm was immediately identified; its walls were thin and blu-

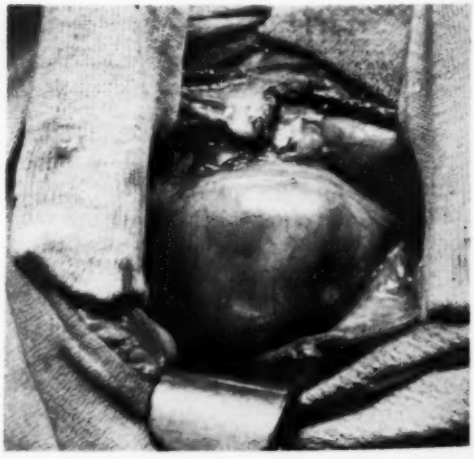

Fig. 5. Case II. Appearance of the superior vena caval aneurysm at surgery.

ish, and the blood could be seen swirling within it (Fig. 5). A large vein (not shown in the illustration) entering the aneurysm on its medial side was thought to be the left innominate. The azygos vein was not identified. The anterior and lateral walls of the lesion were dissected free. When the aneurysm was lifted up for dissection of the posterior wall, the heart action stopped, but was resumed in about two and a half minutes after cardiac massage. Further dissection was not attempted; the free sides of the aneurysm were covered with reactive cellophane, and the chest was closed.

A few hours after operation, pulmonary edema developed, followed by cardiac arrest. Despite cardiac massage and other measures, death ensued.

On postmortem examination, the cause for the vena caval aneurysm was found to be an abnormal insertion of all pulmonary veins (Fig. 6). The pulmonary veins from the left and right lungs joined to form a common trunk, which ascended along the left mediastinal border to enter the left innominate vein. The left innominate, in turn, joined the right innominate to form the superior vena cava, and this was markedly enlarged. The right auricle and ventricle were greatly enlarged, and a wide interatrial septal defect was present. No veins entered the left atrium.

The final diagnoses were complete drainage of all pulmonary veins into the right atrium by way of its tributaries and interatrial septal defect.

Recently two additional patients believed to have identical anomalies have been seen. An angiocardiogram on one showed an aneurysmal dilatation of the right superior vena cava and hypertrophy of the right heart. A left-sided collecting vein could not be identified.

Routine roentgenograms on the other patient showed mediastinal and cardiac contours characteristic of this anomaly.

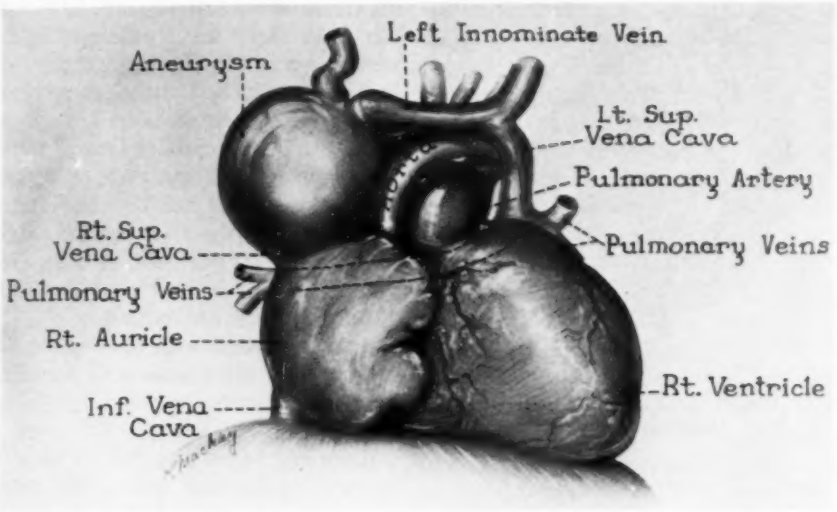

Fig. 6. Case II. Sketch of the postmortem findings. The pulmonary veins entered an anomalous collecting vein, which transported the oxygenated blood from the lungs back to the right atrium *via* the left innominate vein and superior vena cava. A large interatrial septal defect (not shown in sketch) was also present.

Cardiac catheterization revealed oxygen saturations of 16.15 volumes per cent in the superior vena caval aneurysm, and 14.87 volumes per cent in the right atrium. These figures were considered by the cardiologist who did the catheterization to be diagnostic of anomalous shunting of oxygenated blood into the superior vena cava.

Surgery has not been performed on either of these patients, and for this reason complete proof is lacking.

Judging by the many articles appearing in recent years, there is an increasing interest in anomalies of the pulmonary veins. This interest is due in part to the radiologist's and cardiologist's ability to diagnose these anomalies accurately, and in part to the thoracic surgeon's ability to correct some of them.

Many of the published reports deal wholly or in part with the type of anomaly

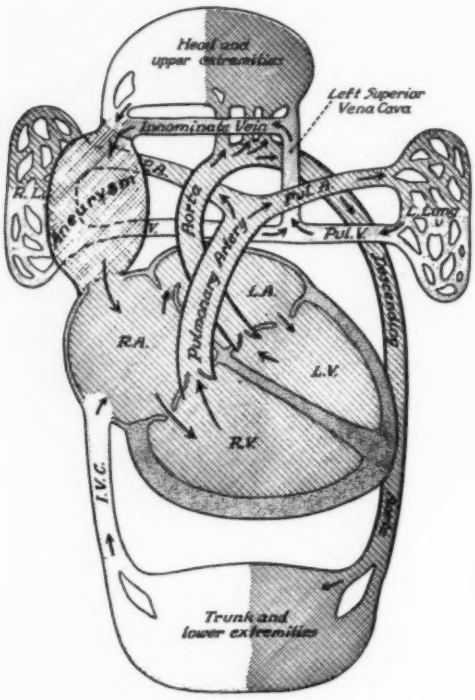

Fig. 7. Drawing showing anomalies in Case II (courtesy of Dr. Helen B. Taussig, the Commonwealth Fund, and The Harvard University Press). Oxygenated blood from the lungs is returned to the right atrium *via* a left-sided collecting vein, the left innominate vein, and the superior vena cava. From here the blood passes to the right ventricle and to the lungs again, or through the interatrial septal defect to the left heart and systemic circulation.

under discussion here (3–17). This lesion is illustrated in Figure 7. It is seen that all blood returning from the lungs in the pulmonary veins passes in sequence into an anomalous left superior vena cava (also called "vertical" vein and "collecting" vein), the left innominate vein, the right-sided superior vena cava, and finally into the right atrium. Thence the blood may go either into the right ventricle (and in so doing repeat its course through the lungs) or may be shunted through an interatrial septal defect into the left heart and thus out into the systemic circulation.

In this anomaly the superior vena cava on the right transports all the oxygenated blood returning from the lungs, together with its usual content of unoxygenated venous blood from the upper half of the body. This results in an aneurysmal dilatation.

Smith (13) has classified pulmonary venous anomalies into three major groups as follows:

Group 1. Incomplete drainage of the pulmonary veins into the right atrium or its tributaries. In 75 such cases, some of the pulmonary veins entered the superior vena cava in 35, the right atrium directly in 18, and the left innominate vein in 16 cases. In several instances the anomalous vein entered the coronary sinus, the inferior vena cava, the azygos vein, or the left subclavian vein. It has been estimated that cardiac decompensation is unlikely to occur if less than 50 per cent of the pulmonary venous blood is delivered to the right atrium by these anomalous veins. For this reason, a patient with incomplete drainage seldom has symptoms and usually has a normal life span.

Group 2. Complete drainage of all pulmonary veins into the right atrium or its tributaries, not associated with other major anomalies of the cardiovascular structures. Among 33 cases in this category, the pulmonary veins emptied into the superior vena cava in 9 instances, into the coronary sinus in 7, the right atrium in 6, the left innominate vein in 3, the portal vein in 2, and into the inferior vena cava and ductus venosus in one case each. When all pulmonary blood returns to the right atrium instead of to the left atrium, it follows that the patient can remain alive only so long as the foramen ovale or its equivalent is patent, allowing the transfer of the right atrial blood to the left atrium and thence to the systemic circulation. With normal closure of the foramen during the early months of life, death ensues. Of Smith's 33 patients in this group with complete anomalous drainage, only 5 lived beyond eight months of age.

Group 3. Complete drainage of all pulmonary veins into the right atrium or its tributaries, associated with other significant anomalies of the cardiovascular system. In this category there were 23 cases, and in these the anomalous drainage from

the lungs was either into the right atrium directly, the superior vena cava or its tributaries, the portal vein, or a persistent sinus venosus.

The associated anomalies of the cardiovascular system in Group 3 included cor biloculare, interatrial septal defect, inter-

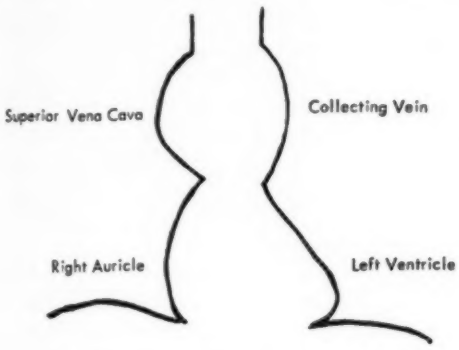

Fig. 8. Figure-of-eight configuration of the mediastinum, characteristic of anomalous venous drainage of the type in Case II of this communication.

ventricular septal defect, transposition of the great vessels, cor triloculare biatriatum, atresia of the pulmonary artery, and atresia of the aorta. Most of the 23 patients died in early infancy. Only 4 lived beyond six months of age, and 2 of these had essentially single atrium hearts, *i.e.*, a large interatrial septal defect that permitted mixing of blood from the systemic and pulmonary circulations as in our Case II.

In fetal life, these anomalies cause no impairment of circulation; the blood entering the heart from the umbilical vessels and inferior vena cava passes from the right heart chambers through the ductus arteriosus to the aorta and into the systemic circulation. The blood which enters the lungs and returns to the right atrium by way of the anomalous pulmonary veins is directed into the left atrium through the patent foramen ovale.

The roentgen findings in these cases are characteristic. In the frontal view, the superior mediastinum is broadened bilaterally—to the right by the superior vena cava and to the left by the anomalous collecting vein. The combination of these two veins and the left and right cardiac borders produces a configuration suggestive of a figure-of-eight (Fig. 8), as described by Snellen and Albers (6). The right auricle and ventricle are enlarged because of the increased volume of blood circulating through them; the left cardiac chambers are abnormally small because of the reduced volume.

Angiocardiographic examination is diagnostic; if technically satisfactory, the films will show opacification, in sequence, of the vena cava, the right heart chambers, the pulmonary artery and its branches, the pulmonary veins, the left-sided anomalous vein, and the left innominate vein. Following this, there will be reopacification of the superior vena cava to some extent. The left auricle and ventricle, which receive blood only through the interauricular septal defect, may show slight opacification immediately following visualization of the right auricle, but they never opacify to the extent seen in the normal patient.

Atelectasis in the right lung is occasionally seen, evidently as a result of bronchial compression by the aneurysm (10). The extent of the process is dependent on the degree of compression and the bronchus involved (Fig. 3A).

A complete discussion of this rare anomaly is not within the scope of this paper. For more information relative to the clinical findings, catheter studies, and theories as to embryological development, the reader is referred to the bibliography, which lists articles covering these phases.

In the few attempts so far made to correct these lesions surgically, results have been disappointing; until a satisfactory technic is evolved most of the patients are doomed to early death.

ANEURYSM OF THE HEMIAZYGOS VEIN

The next case is one of aneurysmal dilatation of the hemiazygos vein, apparently resulting from a long-standing portal hypertension. We are indebted to Dr. Charles Romeo of Dublin, Ga., for this case.

Fig. 9. Case III. Postero-anterior roentgenogram of part of the chest, showing the aneurysm of the hemiazygos vein in the retrocardiac area.

CASE III: *Aneurysm of the Hemiazygos Vein Associated with Portal Hypertension.* A 47-year-old white male was admitted to the hospital with severe icterus, hepatomegaly, ascites, and edema of the lower extremities. While he was in the army, in 1942, a diagnosis of Banti's disease had been made and a splenectomy had been performed. He got along fairly well until 1948, at which time jaundice developed, and between that year and 1951 he was admitted to the hospital three times with similar complaints.

Liver-function tests showed marked cellular damage, a serum bilirubin of 7 mg., and an icterus index of 60 units. The stools were negative for urobilinogen.

Roentgen examination of the chest revealed a retrocardiac widening of the mediastinum to the left (Fig. 9); the cause for this widening was indeterminate. A gastrointestinal series was normal; no varicosities of the esophagus were demonstrated.

The patient's hospital course was steadily downhill, and he died in October 1951.

On postmortem examination, the cause for death was given as portal cirrhosis. The hemiazygos vein in the lower mediastinum showed a large sacculation measuring 6 cm. in length and 4 cm. in breadth, corresponding in position to the mediastinal widening seen roentgenographically. There were several smaller aneurysms, each about 2 cm. in diameter, adjacent to the larger sac. The hemiazygos was quite tortuous, and microscopically showed marked atheromatous changes. There was no mention of any esophageal varicosities in the autopsy protocol.

The final diagnosis was portal cirrhosis with associated aneurysmal dilatation of the hemiazygos vein and atheromatous changes within the wall of this vein.

Gray's *Anatomy* (18) describes two main groups of collateral veins which relieve portal obstruction. These are (*a*) communications between the inferior mesenteric veins and the hemorrhoidal veins which empty into the hypogastric veins; (*b*) communications between the gastric veins and the esophageal veins which empty into the azygos system.

The hemiazygos vein is a part of the azygos system. The aneurysmal dilatation probably resulted from a combination of atheromatous changes in the wall and the abnormally large blood flow through the vein.

ANEURYSM OF THE AZYGOS VEIN

The final case is one of aneurysm of the azygos vein.

CASE IV: *Aneurysm of the Azygos Vein, Hypoplasia of the Inferior Vena Cava, and Cor Biloculare Combined with Pulmonary Stenosis:* A 4-year-old child was admitted to the hospital on April 9, 1948. She was deeply cyanotic, and had been so since birth. For one month prior to admission, she ran a low-grade fever which was never over 100° F. It was unaffected by penicillin.

Physical examination showed an undernourished, apprehensive, cyanotic child. The cyanosis was more marked over the distal portions of the extremities. The head was relatively large. Auscultation of the heart revealed a Grade III apical systolic murmur with a snapping first sound and a low faint diastolic rumble; a high-pitched systolic murmur was heard in the mid-sternal region and at the base; there was also a systolic murmur in the aortic area and a loud bruit in the vessels of the neck. No thrills were felt. The cardiac rhythm was regular.

A hemogram showed a red cell count of 8,650,000 and a hemoglobin of 20.6 gm.; white cells numbered 5,950, with a normal differential count. The hematocrit packed to 80 mm.

Roentgenograms of the chest showed an enlargement of the cardiac silhouette and a broad superior mediastinum (Fig. 10). In addition, there was a hemispherical projection off the mediastinum just above the right hilus; the nature of this latter lesion was indeterminate.

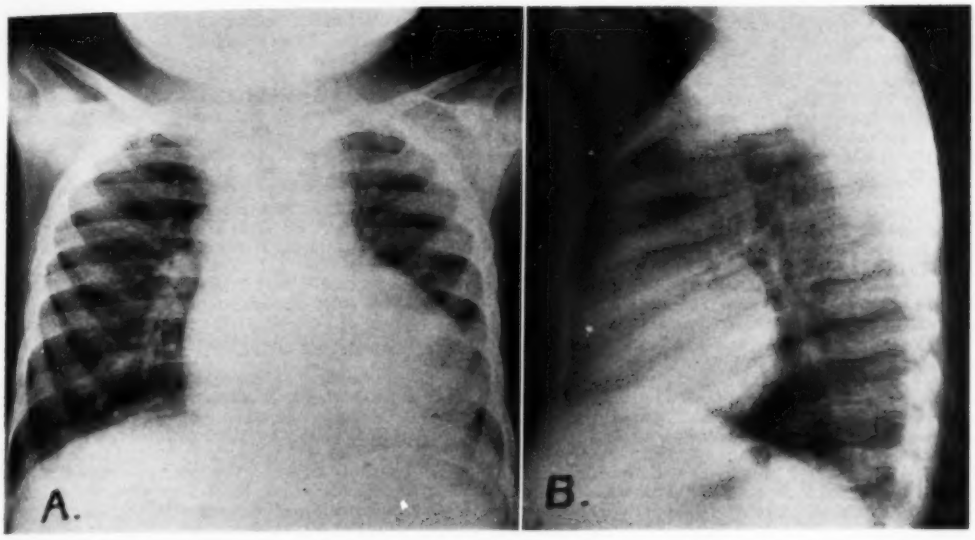

Fig. 10. Case IV. Posteroanterior (A) and left lateral (B) roentgenograms of the chest, showing the enlarged heart and the broad mediastinum. The aneurysm of the azygos vein projects to the right just above the hilus of the right lung.

The preoperative diagnosis was probable tetralogy of Fallot, and the patient was prepared for surgery.

Under almost straight oxygen inhalations, the deep cyanosis failed to clear. After consultation, the decision was made to proceed, and a right thoracotomy incision was made. The cause for the localized mediastinal widening was immediately apparent; it was an aneurysmal dilatation of the azygos vein, extending for several centimeters proximal to its entrance into the superior vena cava. The blood within the sac was under tension. The inferior vena cava was hypoplastic; the superior vena cava was distended.

Before any surgical correction could be started, irreversible cardiac arrest developed, and the patient expired on the table.

Postmortem examination revealed a very large two-chambered heart, consisting of a single atrium and a single ventricle, greatly distended with blood. The orifice of the pulmonary artery measured only 3 mm. in diameter. The azygos vein at its entrance into the superior vena cava was described as "huge." The superior vena cava was distended; the inferior vena cava was smaller than normal.

The aneurysmal dilatation of the azygos vein probably resulted from one or more of the following factors. First, there was hypoplasia of the inferior vena cava with resultant shunting of blood through the azygos system. Second, there was peripheral venous hypertension produced by the pulmonary stenosis and the cor biloculare. Lastly, there were imperfect valves in the azygos vein at the point where it turns anteriorly over the root of the lung, and these may have contributed toward localizing the marked dilatation to the region where the vein entered the superior vena cava.

SUMMARY

Four cases of venous aneurysm of the mediastinum are presented, and some of their features are discussed: a congenital aneurysm of the superior vena cava; an aneurysm of the superior vena cava resulting from an abnormal insertion of all the pulmonary veins; an aneurysm of the hemiazygos vein, resulting from a long standing portal hypertension; an aneurysm of the azygos vein, resulting from a congenital anomaly of the heart (cor biloculare and pulmonary stenosis) and hypoplasia of the inferior vena cava.

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SUMARIO

Aneurismas Venosos del Mediastino

Preséntanse 4 casos de aneurisma venoso del mediastino, discutiéndose algunas de sus características: un aneurisma congénito de la vena cava superior; un aneurisma de la vena cava superior proveniente de una inserción anormal de todas las venas pulmonares; un aneurisma de la vena acigos menor, debido a prolongada hipertensión porta; aneurisma de la vena acigos mayor, debido a cor bilocular y estenosis pulmonar y a hipoplasia de la vena cava inferior.

DISCUSSION

Leo G. Rigler, M.D. (Minneapolis, Minn.): The increasing interest in congenital heart disease has changed our conceptions radically and made life for the radiologist much more complex. Gone are those happy days when we thought we were pretty good if we could suggest a patent ductus or a tetralogy or perhaps a septal defect. The woods seem to be full of infinitely more complex processes, all of which had no doubt been previously described but are now being drawn to our attention through increased diagnostic efforts.

Such an unusual case as Dr. Leigh's first (that is, the localized aneurysm) is of value even though he has never seen another like it. We certainly have not seen a similar one. It is of value because it illustrates very well the striking effects of changes in intravenous and intra-alveolar pressures upon vascular structures in the neck. Dr. Leigh demonstrated that very well.

I would say that anomalous pulmonary drainage is not so uncommon. In our own hospital Dr. Jorgens and Dr. Levin, who have been doing our cardiac roentgenology, have seen 15 cases with distinctive roentgen findings. I believe it would be a disservice to classify such cases as venous aneurysms of the mediastinum even though aneurysmal dilatation is present, for the findings are due to the abnormal pulmonary drainage rather than to the venous aneurysm.

It should be noted, I think, that the diagnosis of anomalous pulmonary drainage can be effectively established through cardiac catheterization by fol-

lowing the roentgen opaque catheter under the fluoroscope, in addition to determining the oxygen saturation.

Some of these cases, for example, may not produce such marked shadows in the mediastinum; yet the insertion of the catheter will give evidence of the process.

I would like to show a few slides to illustrate this. Here, for example, is a case with some enlargement of the mediastinum above and a good deal of enlargement of the heart. The catheter is seen coming through from the superior vena cava into the right pulmonary vein. This is a partial anomalous pulmonary venous circulation.

In the second case the enlargement is somewhat similar to that in one that Dr. Leigh showed. Here you see the catheter coming through into what we call the left vertical vein rather than the left vena cava, since most of the embryologic studies would seem to indicate that this is not a true left vena cava.

Dr. Leigh has described very well the pathological physiology of both complete and incomplete anomalous pulmonary drainage. The most striking examples of this group, from the standpoint of the radiologist at least, are those showing a figure-of-eight configuration, concerning which he spoke. I emphasize this because, if this picture is seen, it is so characteristic that one can make the diagnosis almost certainly from a simple postero-anterior view.

Doctors Levin and Borden[1] from our department have recently reported 4 cases and in each one the picture was so typical that it was unmistakable, all having been later proved by cardiac catheterization or operation.

I would like to show you a few of these, merely to bring this home. In this case, as you see, there is not such a big dense shadow, but there is the large superior mediastinal shadow of which Dr. Leigh spoke. There is a very massive enlargement of the right ventricle as well.

Here is another case in an older individual, showing the same sort of typical shadow in the superior mediastinum.

In regard to the matter of cirrhosis and enlargement of the hemiazygos vein, we were interested to note that in our Veterans Hospital some 30 cases were studied in which there were esophageal varices secondary to cirrhosis. The azygos vein and hemiazygos vein were not distended early in the disease but became distended only after congestion in the lungs occurred.

It should be pointed out that the azygos vein itself will become very prominent in case of cardiac failure—obviously not as large as in the case which Dr. Leigh showed but large enough to lead perhaps to some misapprehension.

I would like to point out one more thing about the azygos vein, and that is, if one makes ordinary planigrams of the right hilus, the azygos vein will stand out very, very prominently even when it is normal. Occasionally it may lead one astray in the direction of thinking that it is abnormal, but in the planigraphic study with relatively short focal-film distances it will appear as a very prominent shadow even though it may be entirely normal.

[1] Radiology **63**:317, September 1954.

A Combination Film Changer for Rapid or Conventional Radiography[1]

LEO G. RIGLER, M.D., and JOHN C. WATSON, R.T.

In a previous publication (2) we reported, in preliminary fashion, the production of a new rapid film-changing device which would be useful for general routine radiography. At that time the unit was in the course of preparation and only an experimental model was available. Since then a practical unit has been made and we have been able to test the device in practical clinical radiography.

The history of the development of rapid film-changing cassettes and their utility in vascular radiography has been adequately reviewed by Scott (3). He is responsible, to a major degree, for the first rapid film-changing device utilizing roll film, although Dotter and his associates (1) no doubt also used roll film at a very early period. Since the original contributions on this subject, numerous papers have appeared and many types of apparatus have been designed to accomplish a similar purpose. The idea, however, of using a continuous strip of film, with intermittent contact with intensifying screens and automatic separation of each film frame at the end of the exposure, for general radiography, has not hitherto been proposed. The desirable features of such a procedure were detailed in our earlier paper. Elimination of individual cassettes with their intensifying screens, the tremendous reduction in darkroom procedures, the great increase in speed in radiography were all pointed out. No less than eight important advantages of such a unit over the present conventional procedure, utilizing a single cassette and screens for almost every exposure, were listed. Furthermore, the unit is so built as to permit, when desired, four to five exposures per second, so that it would fulfill almost all the requirements of cardiovascular and cerebrovascular radiography, at least for clinical diagnostic purposes.

The device has two unique features which make its use in such flexible fashion possible. The first is that the x-ray control unit leads the exposure, permitting intermittent rapid film work or multiple exposure on one film, as desired. It is possible to vary the film-changing speed during the procedure. The second feature is the cutting blade which automatically separates each film frame at the end of the exposure, permitting interruption of the procedure at any point and processing of the film or films already exposed.

It should be noted that the mechanical work, the development of the many ingenious features which may make this device so useful in such a wide variety of radiographic procedures, has been done by Mr. Karl Kallenberg and Mr. Robert Sardeson of the Pako Corporation, with the consultation and immediate help of Mr. Watson, co-author of this paper. The engineering work has proceeded apace, since our preliminary report, in the research unit of the Pako Corporation, so that a more detailed description of the rapid film-changing unit is now possible.

The device is composed of three principal parts: an operational unit comprising the major mechanism of the film advancing process, a supply magazine, and a film receiver (Fig. 1). The operational unit can be mounted in any radiographic table in place of the conventional Bucky diaphragm. For our experiments, Mr. Watson redesigned a table to permit the operational unit to travel beyond the end of the table on a pair of rails which telescope into the table when the unit is in operation (Fig. 2). The purpose of this feature is to permit the changing of the supply magazine, which contains the roll film, and of the film receiver, rapidly and easily with-

[1] From the Department of Radiology, University of Minnesota Medical School, Minneapolis, Minn. Presented at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13–18, 1953.

Fig. 1. Component parts of the rapid film unit. The major portion of the unit is resting on rails with the top open, exposing the intensifying screens. The film magazine has been removed and is on the table top, open to show the roll of film. The receiver for the cut film is also shown open on the table top.

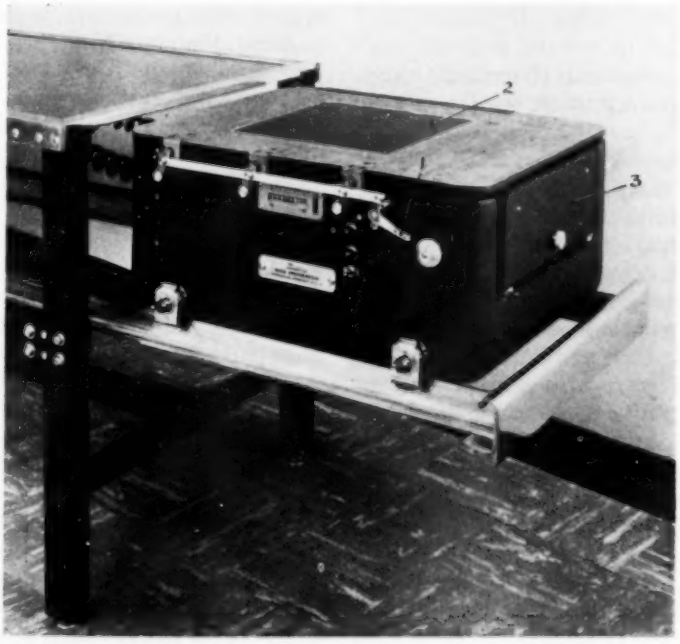

Fig. 2. The assembled unit closed, with the light-seal (1) open, is shown resting on the telescoping rails. It can be positioned under the table or pulled out beyond for loading and unloading and for removal of the receiver. Exposure area (2) and film magazine (3) in position are shown.

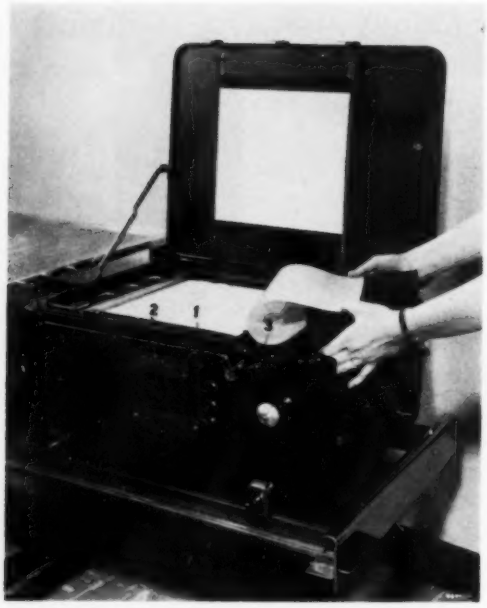

Fig. 3. Roll-film magazine being attached, the film being held in place by the spool. The leader of film which will be placed between the screens is shown projecting. This may be an uncoated piece of film. Controls and signal lights (1), exposure counter (2), light-seal lock in closed position (3) are shown on the side of the unit.

out removing the unit from the table. Under such circumstances, the operational unit becomes a somewhat permanent installation in much the same sense that the usual Bucky diaphragm is a permanent installation within the table itself. Movement to the end of the table is required only for reloading the supply magazine with new roll film or for removing the film receiver which contains the exposed films. Although this type of adaptation seems the most effective, other methods by which the standard radiographic table could be modified to permit rapid and easy access to the film receiver may be used. The complete unit is so arranged that it can be moved up and down the x-ray table, for purposes of positioning, in much the same manner in which a Bucky diaphragm is moved.

The operational unit itself includes the motor, a pair of intensifying screens, a wafer grid, a film-driving mechanism, a clutch and brake assembly, a cutting mechanism, and a device for bringing the screens into close contact with the film.

The supply magazine (Fig. 3) is essentially a light and x-ray-proof device to hold the unexposed film roll. It is designed for attachment to the operational unit in a lighted room. Roll film is being supplied by the various film manufacturing companies and can be made in any desired size.

The film receiver (Figs. 4 and 5) has been designed to receive the cut films and has within it a sequencing arrangement allowing for storage of from 1 to 50 cut films in the order in which they were exposed. This involves certain advantages in being able to determine the sequence in which the films were made. In addition, it is proposed that each film frame be numbered automatically, either in the process of the film manufacture or by a numbering system on the operation unit.

As pointed out previously, this unit is to be used for routine radiography, and for this reason the film receiver may be removed for purposes of film processing after a single film has been exposed, or after any number up to 50. When the film receiver is removed and passed into the darkroom, it is replaced by another empty film receiver so that the unit can be used immediately, while the previous batch of films is being processed.

The operation cycle of the unit is somewhat as follows. A spool of film is placed in the supply magazine in the darkroom. This magazine is closed, with approximately 12 inches of film projecting from it through a light-sealed slot. The first film frame, therefore, becomes a leader and is, of course, wasted in the process. An uncoated piece of film may be used for this purpose to reduce the cost. The supply magazine described above is then taken into the x-ray room, the operational unit is brought out beyond the end of the table, and the top of the unit is opened much in the manner of a cassette, which exposes the screens. The leader is placed on the bottom screen, the supply magazine is hooked onto the operational unit, the

Fig. 4. Position of film receiver under the unit. It is shown here closed by its lightproof shutter.
Fig. 5. The receiver has been opened in a light room, although normally this would be done in the processing room. The cut films which were contained are exhibited.

unit is then closed, putting the screens immediately into contact with the leader film (Fig. 3). Closing of the unit also opens a light seal on the supply magazine. The latter permits easy passage of film but at the same time affords complete protection from light and roentgen radiation.

The unit is ready for use. An x-ray exposure is made, which clears the leader frame from the exposure area and prepares the unit for continuous operation from then on until the roll is exhausted. This first exposure also insures that the combination x-ray and film unit circuits are working properly for purposes of later exposures. The x-ray timer may then be set for the desired exposure time and the first radiographic exposure is made. During the exposure, a complementary action takes place in the unit, cocking the mechanism whose function it is to release the screens and advance the film. This complementary mechanism, with preliminary preparation, permits very rapid advance of the film and rapid action throughout, but with complete absence of motion or vibration during the time of exposure. The duration of exposure is immaterial to the operation of the unit, as no action occurs during the exposure with the exception of the cocking action previously mentioned.

Immediately on termination of the exposure the screens separate. This very action sets in motion a complementary action which cocks the film-cutting mechanism. The film advances by means of a positive, non-slipping, piercing device, for a previously determined length, depending upon the frame size to be used in this particular unit. The piercing device is a wheel operating with sharpened phonograph needles which perforate the film along its margin and thus rapidly and smoothly advance the film. During the film advance, energy is being stored for operating the film-cutting mechanism. The cutting mechanism is a Helex blade and bar assembly which permits cutting in somewhat rotatory fashion, a principle long established as permitting smoother cutting in extremely short periods of time. When the film has advanced the

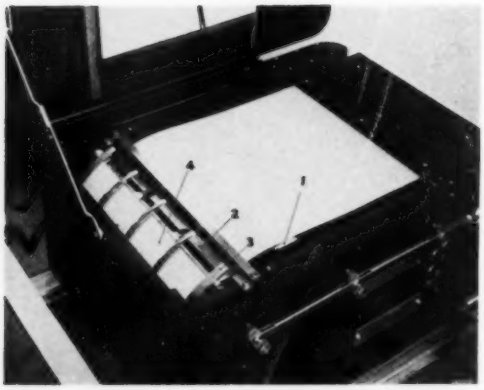

Fig. 6. The mechanics for handling film are shown. 1. Wheels with phonograph needle points for advancing film. 2. Knife which cuts film. 3. Guides to carry film into receiver. 4. One film just being carried into receiver.

full length, the screens immediately go back into contact with the new film, which is now in position. The closing of the screen contact at the same moment actuates the cutting knife and bar, which works with lightning speed, separating the piece of film which constitutes the first frame. A pair of driving rollers operated by a friction clutch at this time engages the cut exposed film and moves it to a receiving slot in the film receiver. During the second exposure, the first exposed film moves from the slot in the receiver to the storage area, thereby freeing the receiving slot to accept the following film. The storage area can accept films only in the rotation in which they have been exposed. The vital parts of the mechanism are exhibited in Figure 6.

At any time upon completion of a single film, a single examination, or a series of examinations, the receiver can be removed in a lighted room for transport to the darkroom for processing (Figs. 4 and 5). This is done by pulling the unit to the end of the table, as previously described. Protection against x-ray exposure, both of the films in the receiver and in the supply magazine, is incorporated in the operational unit itself. As a result, both the receiving unit and the supply magazine are light and easily handled. The clutch and brake assembly upon which the entire action depends is unique in that the molded brake band is made of a rubber material of extreme braking effect.

We are planning that two units should be made. The one shown in Figure 1 is specifically intended for very rapid serial film use and will deliver films at the rate of about four per second. Such a unit could be used for routine radiography as well, but will not carry as large a film roll as a special unit planned specifically for routine or conventional radiography. The latter device will permit films to be made at a maximum rate of one per second and will be suitable for all types of radiography. The rate of film movement in such a unit is of no importance, since the exposures will determine the advance of each frame. As a result, the rate may be from one per second to any speed less than that.

It is to be noted that the number of films on a roll will depend upon the use for which the unit is designed. For rapid film radiography, where it is important to move as many as five films per second, we feel it is desirable to use a relatively small roll containing no more than 30 film frames. Under such circumstances, an entire roll might be used up in one separate procedure; or the roll might be used for several procedures, depending upon the circumstances. For example, in certain studies with contrast cardiography it might be necessary to use as many as 30 exposures, although it seems unlikely that more than that would ever be required. For cerebral angiography, one such roll might well serve for four or five cases. On the other hand, if the unit is to be used primarily for routine radiography in which the films need not be moved more rapidly than one per second, a roll containing 100 frames could well be used. The objection to the larger roll is simply the degree of lag which this produces in the operation of moving the film.

A feature of this device which is of great importance is that the whole mechanism is led by the x-ray exposure rather than by the timing mechanism within the device itself. As a result, by leaving the unit

set for single frame advance, it is possible to make an exposure without moving the film at all. This would permit dividing the film by suitable lead protection so that multiple exposures on one frame could be made if desired. Control of the film motion in the unit is positive at all times, thus allowing operation of the unit in any position, vertical, horizontal, or lateral. It will, therefore, be possible to use two units at right angles to each other for simultaneous radiography.

For purposes of our first studies we have used a Schönander wafer grid mounted under the front screen in order to expedite the procedure. There is no reason, however, why the device could not be used with a reciprocating Bucky diaphragm, of the usual type, which would ride above the unit.

It is obvious that many problems arise in the use of such a unit and many devices have had to be provided to overcome some of these problems. The matter of getting good screen contact and of maintaining it is, of course, of the first importance. As far as we can determine, this has been effectively managed. Second, the release of the screens rapidly so that there will be no abrasion of the film and no undue wear on the screens as the film is advanced has also been, so far as we can determine, completely accomplished. A third problem which arose in the course of our studies was the tendency to accumulate static but this, too, has been eliminated.

One of the unique features of the machine is the reciprocal complementary actions which take place within it. It is this feature which permits such rapid motion without delay and without vibration. The other distinctive development is the use of the Helex cutting blade, the extremely rapid action of which is startling to behold. Here again the reciprocal complementary actions permit the blade to work in the very small fraction of a second permitted it.

Owing to unforeseen difficulties of manufacture, the most thorough clinical trial has so far not been possible. Nevertheless, we have now done many angiocardiographic series, several cerebral angiographic series, several splenoportograms, and a large number of films of the stomach, gallbladder, and skeleton. Examples of some of these are reproduced in Figures 7 to 10.

Fig. 7. Postero-anterior view of the stomach. The entire cut film is here shown exactly as it comes from the processing room. Note the perforations and the unexposed margin along each side thus reducing the exposure area to 11 × 11 inches. Reasonably good detail and contrast are present in this over-filled, dilated stomach. This is one of a series of 8 films which can be made in one and a half minutes using the film changer.

The test films, as illustrated, show excellent contact, are generally free from abrasion and static. Our experience thus far indicates that the unit is practical, gives little or no mechanical difficulty, and permits rapid use.

It is our impression, on the basis of our experiments thus far, that this unit can be produced in a series of different film frame sizes. The first unit for general purposes utilizes a roll 12 inches wide, cutting each film frame 12 inches long. The exposure area is 11 × 11 inches, the borders being blocked out and perforated by the advancing mechanism (Fig. 7). There appears to be no mechanical reason why it cannot be produced for 14 × 17 inch films so that it may be used for routine

Fig. 8. Angiocardiogram in a case of mitral stenosis. The original has been trimmed for purposes of publication. The larger size film is much more suitable for angiocardiography in the adult. Notice the good contrast of the filled left atrium and left ventricle and of the aorta. In such cases the flexibility of speed is of great importance. It is possible to run such an angiocardiogram for forty-five seconds to demonstrate the slow emptying of the left atrium by slowing the speed after the first three seconds during the procedure.

rapid chest radiography. Under such circumstances it would approach the time-saving character of photofluorography and have all the advantages of full-size film. We also feel that it could be produced for small-sized films, such as 8 × 10 inch, for gallbladder and other types of serial radiography.

It is obvious that the chief utility of this unit for routine radiography will be in institutions or departments where there is some selection of cases for different rooms, for the chief objection to the unit for routine studies lies in the inflexibility of film size. Nevertheless, it could be used to some advantage in almost any room by careful selection of cases and by positioning with protection of a portion of the film so that several exposures could be made on one film. In general, it would be necessary to use a unit with a film size at least as large as the maximum required for the type of examinations to be conducted on the table. As a result, some wastage of film will occur, but the great advantages of facility, of handling in the darkroom, of simplicity, of loading once for 30 or even for 100 exposures instead of 30 or 100 times, the elimination of the numerous cumbersome cassettes now used, and the

Fig. 9. Angiocardiogram, right oblique view, in a child with multiple anomalies. The contrast medium in the large vessels of the neck, the anomalous vessels in the upper mediastinum, the descending aorta and in the hepatic veins is clearly delineated. The film was trimmed for purposes of publication. The radiographs were exposed at the rate of four per second.

many screens which are so subject to damage would more than compensate for some excess use of film. One set of screens has been subjected to some 2,000 exposures without showing any signs of wear.

We have not yet explored all the possibilities for film identification. Obviously, lead markers could be used here as with conventional cassettes. Likewise, the ordinary photographic type of marker could be used by protecting the operational device suitably. We have felt strongly that the films on one roll should be numbered serially at the time of manufacture

so that the sequence of exposures could be easily determined by the number of each frame. It would be possible, further, to use a simple lead numbering system to avoid the large amount of lead ordinarily placed on a film, the number being used as a guide for the film marking after the films are dry. So far as we can determine, the use of this device should not militate against any type of identifying device presently used. Furthermore, it presents the advantage of bringing all the films made on one case, at one sitting, into the darkroom simultaneously.

For purposes of rapid serial films, such as are used in angiocardiography or cerebral angiography, or in various venous and arterial studies, the possibilities of this unit seem to be superior to any presently available in this country. For practical purposes, a maximum speed of five per second will accomplish almost all that is necessary in the fields of rapid serial film usage. In certain research projects, more rapid speeds up to ten or twelve per second may be desirable, but these can only be attained by most extraordinary methods.

The unit has the great advantage of permitting rapid serial film usage occasionally, while being of considerable utility as well for routine radiography. This should make it practical for smaller institutions which are hesitant about investing a large sum of money in a unit which might be used only once or twice a month.

It is obvious that the usefulness of such a unit and its ability to withstand the stresses of heavy work cannot be determined by its appearance or the theoretical details of its mechanism. Only long clinical experience will answer such questions. We hope to report further on its practical usefulness in a functioning capacity.

Fig. 10. Spleno-portogram ten seconds after splenic puncture and injection of 70 per cent Urokon. Both the extrahepatic and intrahepatic portal circulation are shown. Suction tube is in the stomach. The film is exhibited exactly as processed. Note the unexposed perforated margins. The size of the film makes such studies feasible. Fifteen films were exposed at the rate of one per second. It would be possible to expose 30 films at variable rates if desired.

SUMMARY

Further studies of a new type of rapid film changer are presented. Practical experience with a completed unit indicates its utility both for angiography at speeds up to five exposures per second and for conventional radiography at any speed. In angiography, films of good detail, showing excellent contact and relatively free of abrasion and static are produced. Details of the cardiac structure are clearly apparent. It is possible to shift speed during the procedure, giving greater flexibility. Because the film is cut at the end of each exposure, it is possible to process a test film for assurance as to positioning and exposure factors before each angiogram.

For routine radiography this unit permits time-saving procedures and is especially valuable when multiple films are to be made of any anatomical part, as in serial gastrointestinal studies, radiography of the spine, etc. It eliminates the necessity for changing individual cassettes, loading and unloading each in the darkroom.

The mechanics of the unit are described. Illustrations of its use in various procedures are shown.

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SUMARIO

Cambiapelículas de Combinación para Radiografía Rápida o Corriente

Preséntanse nuevos estudios de un nuevo y rápido cambiapelículas. Su empleo práctico en un aparato completo indica su utilidad tanto para la angiografía a velocidades hasta de cinco exposiciones por segundo cuanto para la radiografía corriente a cualquier velocidad. En la angiografía, se obtienen películas con buenos detalles, que muestran magnífico contacto y están relativamente exentas de abrasión y de efectos estáticos. Obsérvanse claramente los pormenores de la estructura cardíaca. Es posible variar la velocidad durante el procedimiento, logrando así mayor flexibilidad. Por cortarse la película al final de cada exposición, resulta posible preparar una radiografía de ensayo, que permite cerciorarse de los factores de posición y de exposición antes de cada angiograma.

Para la radiografía corriente, este aparato aporta procedimientos que ahorran tiempo, resultando en particular útil cuando van a tomarse varias radiografías de cualquier parte anatómica, como en los estudios gastrointestinales en serie, la radiografía de la espina dorsal, etc. También elimina la necesidad de cambiar los distintos chasis, y cargar y descargar cada uno en el cuarto obscuro.

Descríbese la fase mecánica del aparato y muéstranse ejemplos ilustrados de su empleo en varios procedimientos.

DISCUSSION

Wendell G. Scott, M.D. (St. Louis, Mo.): Dr. Rigler and Mr. Watson, working together with the Pako Corporation, have brought forth a most ingenious unit and in so doing have made two basic contributions in rapid serialized radiography—first, in arranging the x-ray control to lead the exposure, which permits intermittent rapid exposures or multiple exposures on the same film, thus providing a much more flexible unit; second, the incorporation of a cutting blade which automatically separates each film frame and does away with a lot of the problems of taking up the exposed roll film. These developments make it possible to use the unit for general radiographic work.

There are several advantages, which Dr. Rigler listed in an earlier paper, in the use of roll film as compared to cut film and I would like to mention them briefly.

The roll film eliminates the cost and upkeep of numerous cassettes and screens. The cost is lower as the cost of packing is eliminated. The roll film also eliminates time and effort in the transport of cassettes as well as their loading and unloading. Where photographic film identification is used, the roll film reduces errors, since each frame on the roll film is automatically identified. The use of roll film also makes the location of the processing room less important and decreases the amount of space required for film storage.

The application of Dr. Rigler's device opens numerous new possibilities, particularly in large institutions where individual rooms are used for separate procedures. Think how nice it would be to have this unit set up for routine chest radiography. At the end of an hour or two you could take the cassette box with the exposed films and process them all at once.

Also it would be a distinct advantage for use in routine intravenous pyelography or in any procedure where a series of five or six exposures or more are required. The same would be true for the examination of the stomach. If the routine fluoroscopic and spot film work are done in one room, the patient could be sent into the adjacent radiographic room and have a series of films made in quick sequence on this equipment. There would be no more handling of cassettes, and at the completion of the examination all the films would be taken as one group into the dark room. This would also apply to gallbladder examination.

Now what are some of the disadvantages?

First, the equipment is increased in size and bulk over that of the usual Potter-Bucky grid that fits under the table. Of course, this is going to be a hard problem to solve. However, the essayists have worked out an ingenious method by bringing the equipment out to the end of the table. This still makes adaptation to the radiographic table that is

equipped for fluoroscopy difficult. Consequently, I think it is likely that Dr. Rigler's unit will probably develop into a specialized unit.

I would like to encourage Dr. Rigler in the development of this unit for fast angiographic examinations with exposure rates from ten to twelve per second. I think five is a big step forward, but I know there are times in the very first second that you need a faster rate of exposure.

I would like to ask whether the perforations that are produced by the wheel of phonograph needles used to advance the film make the edge of the film rough and liable to tear. I don't suppose they do. I also wonder if the reciprocating Bucky will move fast enough for exposures of five per second. In our experience we have not been able to use it satisfactorily at that rate.

I hope that Dr. Rigler will incorporate an automatic meter for recording the amount of unexposed film that is still left in the machine, so that one will know how many more feet of film are available for the next examination.

Just to keep the record straight, and I know Dr. Rigler knows this, it was Dr. Hans Jarre who produced the first unit that utilized roll film for serial radiography. My contribution was to make the first practical and fully automatic roll film unit for fast serial radiography. The development of this new unit is a big forward step and I am certain that eventually we are going to see more uses for the roll film than just for fast radiography. The essayists have made a real contribution in devising a satisfactory machine that provides firm and constant contact between the two screens and the film. That has been a tough problem; they have overcome it and they are to be complimented.

Charles T. Dotter, M.D. (Portland, Ore.): The economy involved in using a single cassette instead of a hundred cassettes during a given morning's routine radiographic work is significant.

The use of a film-cutting mechanism such as Dr. Rigler has described makes this a practical possibility for large departments. It is worth considering, however, that a device producing all the radiographs in one continuous roll would offer still further operational economy. In this way the economy would apply to all steps in film processing. It is far simpler to process one hundred radiographic exposures when they are incorporated in a single roll of film than it is to clip separately one hundred films (at four hundred separate corners) to one hundred easily destructible hangers. Unit or roll-film processing would obviate certain sources of artefacts (such as contact spots and film scratches), offering instead uniformity of development and fixation. Adequate drying apparatus has yet to be commercially produced but presents no particular problem in design or construction. The use of roll film cassettes and processing will probably someday be routine for certain applications (chests, gastrointestinal examinations) in large radiographic departments.

Dr. Rigler (*closing*): Mr. Watson and Mr. Kallenberg have been giving me rapid instructions as to how to answer the various questions that have been asked.

I might say, with regard to the perforations about which Dr. Scott asked, they are very tiny and we have noticed no particular roughness. I don't think that would bother us at all.

With regard to the diaphragming, we had in mind to use a reciprocating grid for routine radiography, where time is not important, but if one were doing angiography, where we wish to make exposures in one tenth of a second or less—I suspect that a wafer grid would still be necessary.

There is already in the unit an automatic counter which determines the number of films left on the roll, so we have provided for that.

I appreciate Dr. Scott's discussion particularly because he covered a good many points which I omitted from consideration simply because of the limited time at my disposal, and I am sure he has reviewed for you many other factors to which we had given some thought.

We have thought a good deal about the matter of not cutting some films; in fact, we thought about trying to move the position of the knife between one exposure and another so one wouldn't have to be stuck with the same sized film frame for every exposure, but I think the mechanical difficulties are of such an order that they might make the machine very difficult to use.

Obviously we couldn't expect the Pako Corporation to help us develop a unit which would tend to eliminate their own developing units, so that might be a factor. Our own experience with the processing of roll film has not been a very happy one and, despite the numerous perforations which have to be made, we are at the moment a little more inclined to develop separate films than roll films.

Hodgkin's Disease and Amyloidopathia[1]

A. HOCHMAN, M.D., and P. CZERNIAK, M.D.

In 1840 Rokitansky (1) first described a pathological condition which he called "lardaceous disease." Later Budd (2) designated this condition as "waxy disease." The name "amyloidosis" was given by Virchow (3) in 1854, and is still used, although without justification. From the pathological point of view, there is no degeneration of cells, but rather a deposit of a polysaccharoid is secreted by the intercellular substance. This mucopolysaccharoid is related to the proteins (possibly to a special type of globulin) which are found in the blood but which produce a pseudo antigen-antibody reaction with precipitation of amyloid substance.

Amyloidopathia may be primary, *i.e.*, without obvious cause, or secondary to other conditions. These latter include: (*a*) suppurative chronic foci in the body, as tuberculosis, osteomyelitis, bronchiectasis, abscess, etc.; (*b*) non-suppurative chronic processes, as syphilis, chronic arthritis, multiple myeloma, malaria, and Hodgkin's disease. Clinically, the primary cases differ from the secondary group in the absence of any signs of a pathological condition which might lead to amyloidosis.

Table I: Cases of Amyloidopathia

Source of Material	Specification of the Condition Leading to Amyloidopathia							
Presented by	No. of Cases	Tuberculosis	Osteomyelitis	Syphilis	Chronic Arthritis	Other Diseases	Unknown Cause (primary)	Hodgkin's Disease
Lubarsch	289	186	64	11	—	22	—	6
Bell	107	54	25	4	7	9	6	—
"Hadassah" Jerusalem	9	—	3	—	1	2	1	2
Total	405	240	92	15	8	33	7	8
Percentage	100	59	23.5	4	2	8	1.5	2

substance in the intercellular spaces of the basal layer of the capillary and arteriolar media. "Amyloidopathia" or "amyloidoforme infiltration" is therefore thought to be a more suitable name (Bell, 4).

From the chemical point of view, the specific substance in this disorder is not amyloid or cellulose, as assumed by Virchow. Even today its exact chemical nature is not known. Krawkow (5), in 1897, suggested that it belongs to the group of the glucoproteins and represents a compound of protein and chondroitin-sulfuric acid. According to Hansen and Eppinger (cited by Budd), it contains neither sulfur nor phosphorus. In their opinion, aminoacid is the base of the amyloid, while the sulfur belongs to the tissues. Altschuler and Angevine (6) described amyloid as a mucopolysaccharoid substance, one of the glucoproteins. Skelton (7) believed that in pathological states leading to amyloidosis an excess of muco-

Amyloidopathia can be produced experimentally in animals by injections of terebenthene and of diphtheroid toxins (in horses) and by continuous feeding of nutrose (sodium caseinate) or cheese (in mice) (8).

STATISTICAL MATERIAL

Amyloidopathia complicating Hodgkin's disease has been described in a small number of cases. Wilks (9) published the first case in 1856. In 1925 Schalong (11) collected 15 cases from the literature, and

[1] From the Radium and Tumour Institute, Rothschild Hadassah University Hospital, Jerusalem, Israel. Accepted for publication in July 1953.

in 1950 Wallace (10) found 29 cases (excluding 5 cases reported by Sternberg which had not been proved by autopsy or the Congo-red test).

In the records of the Hadassah University Hospital, there were found 9 cases of amyloidopathia confirmed by autopsy or the Congo-red test. Among these were 2 complicating Hodgkin's disease, the only ones among 157 cases of malignant lymphogranulomatosis seen in the Radium and Tumour Institute of this Hospital during 1934–51. In 1929, Lubarsch (12) reported 289 cases of amyloidosis, and in 1948 Bell (4) reported 107 cases. The relative etiologic distribution of these and of our 9 cases is given in Table I.

From these figures it would appear that some 2 per cent of cases of amyloidopathia are associated with Hodgkin's disease.

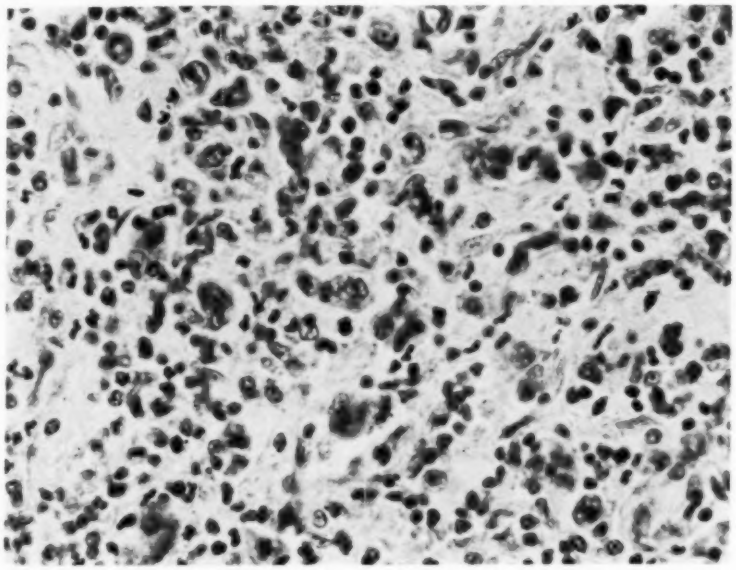

Fig. 1. Case I. Lymph node, showing Hodgkin's disease. ×460.

CASE REPORTS

CASE I: T. B., aged 23, mother of two children, showed the first signs of Hodgkin's disease in May 1943: temperature elevation, enlarged right cervical lymph nodes, and a broadened mediastinal shadow. Her past history was irrelevant.

In September 1943, the diagnosis of Hodgkin's disease was confirmed histologically (Dr. Casper, Beilinson Hospital). Two months later treatment, which was to continue over a span of years, was begun in this Department. During this period the lymph nodes in all regions enlarged progressively and itching occurred. In 1947 the swelling of nodes in the left pelvis greatly increased, resulting in stasis in the left extremity, where epidermomycosis developed, complicated by recurrent erysipelas. The latter yielded promptly to treatment with penicillin and sulfa drugs. During 1943–50 the patient was treated actively, part of the time as an out-patient and part of the time in the hospital. So far as the Hodgkin's disease was concerned she improved after each treatment.

The total roentgen dose in this period was as follows: to the cervical nodes, 4,200 r; the thorax, 2,350 r; axilla, 6,700 r; abdomen, 3,800 r; lumbar area, 10,400 r; pelvis, 11,850 r; inguinal nodes, 5,500 r. In addition, radium applications were given to the cervical nodes (2,000 mg. hr.), the axilla (3,900 mg. hr.), and the inguinal region (1,764 mg. hr.). Nitrogen mustard was administered on two occasions, 24 and 26 mg., respectively. Just before the patient's death, in 1951, a roentgen dose of 1,200 r was delivered to the dorsolumbar area.

The amyloid condition probably appeared in July 1949, when for the first time traces of albumin and multiple leukocytes, but no erythrocytes or casts, were found in the urine. At the same time, the blood plasma showed 4.9 gm. per cent total protein and an albumin-globulin ratio of 2.3:2.6. Cholesterol was normal. The blood pressure was 120/80. No edema was present.

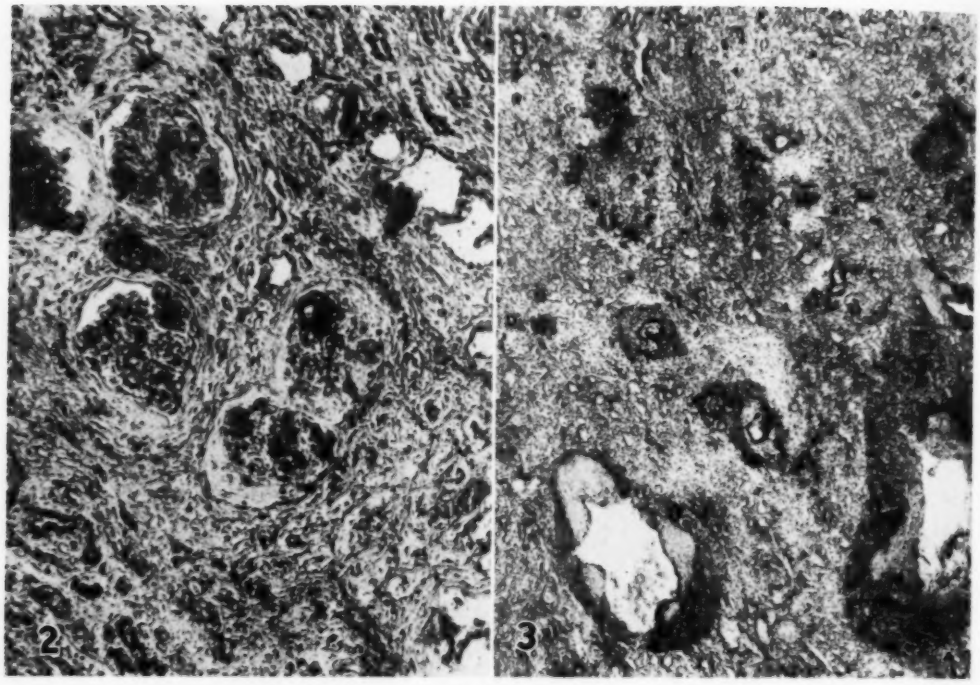

Fig. 2. Case I. Amyloidosis of the kidneys. ×120
Fig. 3. Case I. Amyloidosis of the spleen. ×40

By November 1950, renal function had deteriorated. Albumin in the urine increased to 4 gm. per 1,000 c.c., although the daily urinary output remained normal (1,500 to 1,800 c.c.). The albumin-globulin ratio in the plasma was 1; blood urea, 75 mg. per cent; cholesterol, 480 mg. per cent. The chlorides remained normal. Edema appeared in the legs. The presence of amyloidopathia was then suspected. On Nov. 2, 1950, a Congo-red test was performed according to the technic of Paunz (13)[2], with negative results. After sixty minutes, there was a retention in the blood of 87 per cent of the injected dye, while only 13 per cent was retained by the body tissues.

Ten months later the condition of the kidneys became the main concern, while Hodgkin's disease as such remained in the background. The following observations were made: edema of both legs; albuminuria and normal quantity of daily urine without erythrocytes or casts; hypoproteinemia, low albumin-globulin ratio, hypercholesterolemia, increased urea, creatinin and uric acid; low blood pressure. Ophthalmologic examination was normal.

On Sept. 5, 1951, a second Congo-red test was performed. This revealed a retention in the blood of 45 per cent of the injected dye, which was held to support the impression of amyloidopathia, since it represented an increase over the observation of November 1950.

In arriving at a diagnosis the question arose as to whether we were dealing with Hodgkin's disease complicated by amyloidopathia or whether there was present some other concurrent disease which might result in amyloidopathia. Kahn and Wassermann tests, however, were repeatedly negative, as were Weil-Felix tests and tests for malaria and tuberculosis. The patient died Sept. 17, 1951, twelve days after the second Congo-red test. The postmortem examination confirmed the diagnosis of Hodgkin's disease with amyloidopathia.

Abstract of Autopsy Findings (Dr. A. Behar, Department of Pathology, Hadassah University Hospital). *Lymph nodes:* On external examination of the body no lymph nodes were palpable. Only two groups of internal nodes showed enlargement: (*a*) Nodes at the bifurcation of the trachea were moderately enlarged; the tissues cut with increased resistance, and the cut-surfaces were of a grayish color with many anthracotic spots. (*b*) Periportal nodes were slightly enlarged. On histologic examination, nodes from the axilla, inguinal, and portal regions and from the bifurcation of the trachea revealed changes characteristic of Hodgkin's disease, with numerous large multinucleated

[2] The patient weighed 62 kg.; 6.2 c.c. of 1.5 per cent Congo-red solution was injected intravenously. Blood samples were taken before and five and sixty minutes after injection.

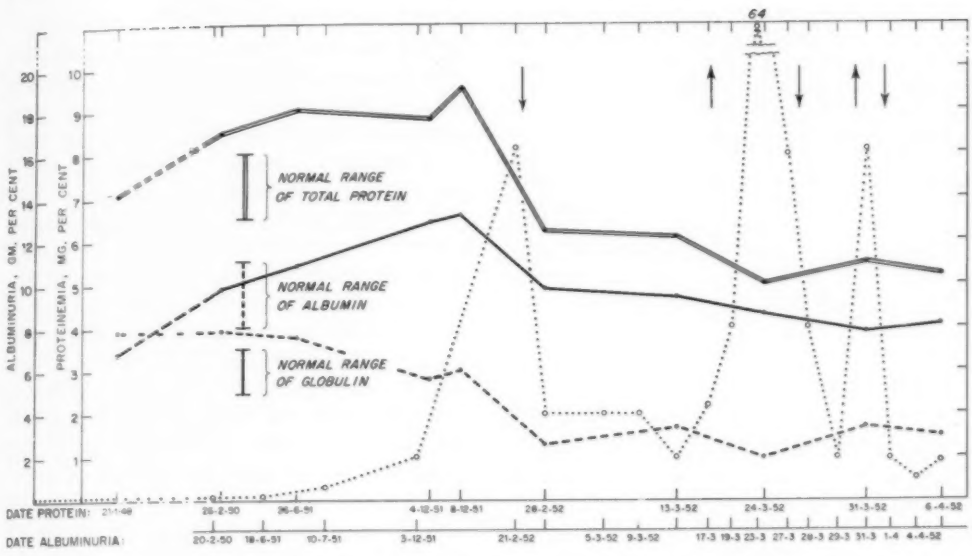

Fig. 4. Case II. Blood proteins and albuminuria in relation to liver therapy. The double line represents total serum protein, the single line serum globulin, and the dash line serum albumin, at the beginning (↓) and at the end (↑) of liver therapy. The dotted line is the albuminuria curve.

cells of the Sternberg-Reed type, large areas of fibrosis and hyaline change, and infiltration of sinusoids by a great number of polymorphonuclear leukocytes, among which were many eosinophils (Fig. 1).

Kidneys, spleen, and adrenals revealed lesions characteristic of amyloidosis grossly and on histologic examination. The deposits of amyloid gave positive staining reactions with iodine, Congo-red, and gentian violet (Figs. 2 and 3). The same staining methods revealed deposits of amyloid in some of the lymph nodes involved by Hodgkin's disease.

Subsidiary findings included acute fibrinous pericarditis, bilateral pleural effusion of about 400 c.c. of clear fluid, and petechial hemorrhages in the pleura and renal pelvis.

CASE II: E. S., a 16-year-old male from Haifa, gave a history of occasional sore throat and malaria in 1943, from which he completely recovered. In May 1943, the first signs of Hodgkin's disease appeared: enlarged lymph nodes, fever, and a characteristic shadow in the chest roentgenogram. The diagnosis was confirmed by biopsy on three occasions. The first showed a picture similar to giant follicular adenopathy and the other two showed typical Hodgkin's lesions. During the ensuing years lymph nodes enlarged all over the body (groins, axillae, neck, peritoneal cavity). The enlarged nodes were occasionally painful. There was no itching of the skin.

Up to April 1952, the patient received repeated roentgen therapy, supplemented by radium and nitrogen mustard. Over a period of seven years and ten months roentgen dosage was as follows: 1,700 r to the supraclavicular nodes; 8,550 r to the thorax; 1,500 r to the cervical nodes (plus 1,440 mg. hr. radium therapy); 1,150 r to the spleen; 1,650 r to the lumbar area; 4,500 r to the inguinal nodes (plus 5,040 mg. hr. radium therapy); 2,050 r to the pelvis. Nitrogen mustard was given in 1949 and 1951, a total of 74.7 mg.

From 1950, severe anemia with leukopenia was present, and anti-anemic treatment was instituted. In December 1951, the first clinical signs of anyloidopathia appeared; the legs became swollen; albumin was found in the urine, increasing from 2 to 64 gm. per 1,000 c.c., but the daily urinary output remained normal and only hyaline casts were found. The plasma cholesterol increased slightly (246–290 mg.); blood urea and chlorides remained normal. The clinical diagnosis of amyloidopathia was confirmed by a Congo-red test performed on Feb. 27, 1952. With the technic used in Case I, only 11 per cent of the dye was found in the blood after sixty minutes, 89 per cent having been retained by the amyloid substance.

Of special interest was the response of the albuminuria, of the plasma proteins, and of the albumin-globulin ratio to treatment with liver extract (Fig. 4). The patient received 15 units daily, immediately following which the amount of albumin in the urine decreased; the serum albumin rose and the globulin fell accordingly, so that the ratio was slightly increased. With discontinuance of liver extract injections, the opposite was observed. This

experiment was repeated three times. The changes were noted immediately after the injections were given. This would suggest that the albumin-globulin ratio may be of importance as an early manifestation of impending amyloidosis.

Numerous other examinations were carried out from 1944 onward. No signs of tuberculosis were revealed; the blood sedimentation rate was always rapid (5′–25′). Weil-Felix, Kahn, Malta, and malarial tests were all negative.

It was concluded that the amyloidopathia which appeared eight years after the onset of Hodgkin's disease was related only to the late condition.

DISCUSSION

These cases raise three points:

1. It is comparatively easy to establish a diagnosis of amyloidopathia in a case of Hodgkin's disease. Attention should be focused on edema, hepatosplenomegaly, albuminuria, absence of erythrocytes and granular casts in the urine sediment, low blood pressure, normal eyegrounds, hypoalbuminemia, low albumin-globulin ratio and hypercholesterolemia, with uremia, a high pH, high levels of creatinin and uric acid in the blood, and renal failure. The Congo-red test is of decisive importance. According to our observations, this may usually be considered positive for amyloidosis if over 40 per cent of the dye disappears from the blood during the first hour (our second case). In our first case a disappearance of 13 per cent was estimated, while the amyloidosis was obviously already present. We believe, therefore, that the test, should be carried out twice, with an interval of some months. If the percentage in this "comparative Congo-red test" increases, we consider it justifiable to make a diagnosis of amyloidopathia, apart from the absolute figures. Prognosis may be established on the basis of the difference in the two tests.

2. What is the relation between amyloidopathia and Hodgkin's disease? Is it only a coincidence or a relation of cause and effect? Apparently the relationship is not coincidental. In the first place, there is no increase in the incidence of amyloidopathia in other diseases, such as tuberculosis or suppurations (Sternberg (14), Fraenkel (15), Short and Castelman (16)). In the second place, in none of the cases mentioned has there been any additional disease present which could have been the cause of amyloidopathia. It can thus be concluded that it was related in some way to Hodgkin's disease. Several possibilities can be contemplated:

1. The x-ray treatment may have caused the amyloidopathia. In other cases, however, larger doses have been administered without this effect. Also, it has been shown experimentally (Domagk, 1928; Fels, 1935; Shields Warren, 1942; Bloom, 1948) that neither single massive nor small and repeated doses can produce amyloidosis; they can cause only degeneration.

2. The presence of a virus or biochemical changes could be responsible for both the Hodgkin's disease and the amyloidosis. This possibility has been much discussed, but no final conclusion is so far established.

3. A third possibility is that the histologic changes in the kidneys in Hodgkin's disease result in the production of amyloid substance. Jackson and Parker (18), however, showed that of 259 cases of Hodgkin's disease, 13 had specific infiltration into the kidney without signs of amyloidosis, and similar findings were recorded in 8 of 32 cases of Hodgkin's sarcoma.

What is the practical value of a diagnosis of amyloidopathia? Grayzel and Jacobi (19) in 1938, and later Trasoff *et al.* (20) in 1944, Lush (21) in 1948, and Skelton in 1951 (7) reported improvement following injection of liver extract in cases of amyloidopathia and chronic rheumatic arthritis. In our second case there were indications of the influence of this extract. In view of this, the establishment of an early diagnosis might be of some importance, since treatment may possibly retard the deposition of amyloid substance and the appearance of uremia. Our second case suggests that the protein level and the albumin-globulin ratio in the blood, systematically checked every three to six months, may afford an early indication of impending amyloidosis.

SUMMARY

The problem of amyloidopathia is briefly described from the historical and pathological point of view. Two cases of Hodgkin's disease complicated by amyloidopathia are presented, being the 30th and 31st cases on record. Amyloidosis appeared eight years after the diagnosis of Hodgkin's disease was established. One patient died from uremia about one year after the appearance of amyloidopathia. In the second case, the condition was ameliorated following liver-extract treatment.

These cases suggest that (1) a comparative Congo-red test may lead to the establishment of the diagnosis where the absolute result of this test is not decisive; (2) that the early diagnosis of amyloidosis may be of some importance, since adequate treatment may possibly retard the deposition of amyloid substance; (3) that the appearance of amyloidopathia worsens the prognosis of Hodgkin's disease and may lead to death from uremia.

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SUMARIO

La Enfermedad de Hodgkin y la Amiloidopatía

Descríbese brevemente el problema de la amiloidopatía desde los puntos de vista histórico e histopatológico. Preséntanse 2 casos de enfermedad de Hodgkin complicada por amiloidopatía, siendo el 30° y el 31° casos registrados hasta ahora. En ambos, la amiloidosis apareció a los ocho años de hacerse el diagnóstico de enfermedad de Hodgkin. Un enfermo falleció de uremia aproximadamente un año después de la aparición de la amiloidopatía. En el segundo caso, la dolencia mejoró después del tratamiento con extracto hepático.

Sugieren estos casos que: (1) una prueba comparativa con rojo del Congo puede conducir al establecimiento del diagnóstico de amiloidopatía cuando el resultado absoluto de la prueba no es decisivo; (2) el tratamiento adecuado tal vez retarde el depósito de substancia amiloidea; (3) la aparición de amiloidopatía empeora el pronóstico de la enfermedad de Hodgkin y puede culminar en la muerte por uremia.

Pyelography for the Diagnosis of Lesions of the Body and Tail of the Pancreas[1]

GEORGE W. CHAMBERLIN, M.D., and IRVING IMBER, M.D.

LESIONS OF THE body and tail of the pancreas are frequently silent until they have reached a large size. Their early detection is often a matter of exclusion, which is, at best, a rather unsatisfactory method of diagnosis. We have been able to detect mass lesions in the body of the pancreas by the changes in the left pyelogram in some patients who had no other demonstrable evidence of the location of their disease. These findings, while they may not always represent early involvement of the pancreas, at least offer a diagnostic clue which may result in discovery of a greater number of resectable lesions. Tumors in this area are more amenable to surgery than those of the head of the pancreas, and their earlier recognition is no longer a matter of pure academic interest.

We present here a series of 6 patients who were found to have either carcinoma, carcinoma with retention cysts, or benign cyst of the pancreas. These lesions presented a complex and bizarre clinical picture. The familiar aphorism, "the first step in making any diagnosis is to think of it," is particularly applicable in these cases.

Benign tumors and cysts of the pancreas are relatively uncommon. Pancreatic cysts produce epigastric or left upper quadrant pain plus a palpable mass in the same region when a reasonable size has been attained. Confirmation of the presence of a cyst requires gastrointestinal and renal x-ray examination.

Cysts may be divided into three groups: congenital, retention, and neoplastic (5). Congenital cysts may be part of polycystic disease. Retention cysts are a result of obstruction of the pancreatic ducts and may be associated with carcinoma. Neoplastic cysts or cystadenomas are rare and multiloculated. The so-called pseudocysts are not situated in the pancreatic substance but in the immediate neighborhood and are usually the result of an inflammatory process (4).

Cancer of the pancreas is a disease of rapid downhill course. It occurs predominantly in the older age group, and males are affected two to three times more frequently than females. The most characteristic symptoms are weight loss, pain, and jaundice. Persistent epigastric pain radiating through to the back is suggestive of involvement of the body or tail of the pancreas when the more common gastrointestinal disorders are excluded. The pain is not characteristic, but is usually constant, rather severe, and exaggerated at night, with a tendency to mimic duodenal ulcer. Weight loss has been observed invariably, by all authors (3). Persistent diarrhea without an adequate explanation may herald the onset of pancreatic carcinoma. Jaundice indicates involvement of the head rather than the tail or body.

During ordinary physical examinations, the findings are notoriously scant. A palpable gallbladder (Courvoisier's law) is diagnostically useful with cancer of the head of the pancreas. Rarely will carcinoma of the body or tail produce a palpable mid-line or left upper quadrant mass. Occasionally distant tumor thrombosis will occur.

The laboratory findings may be helpful at times. Anemia is generally mild, despite the rapid weight loss. Fatty stools, if present, have been looked upon as a classical manifestation. A diabetic type of dextrose tolerance curve is surprisingly frequent but often overlooked. Hyperlipasemia is present in over one-third of the cases (3). By means of duodenal intuba-

[1] From the Reading Hospital, Reading, Penna. Accepted for publication in October 1953.

tion, deficiency of external pancreatic secretion may be determined on occasion. Cytologic examination after the method of Papanicolaou may at times demonstrate malignant cells.

Clinical and laboratory observations may arouse suspicion of pancreatic involvement, and the roentgen study may differentiate lesions of the head from those of the body or tail.

ROENTGEN FINDINGS

The radiologic literature contains little evidence that pancreatic lesions may produce significant pressure effects upon the left kidney. Strang and Walton (9), in a comprehensive review of 58 cases of carcinoma of the body and/or tail of the pancreas, call attention to the gastrointestinal abnormalities seen roentgenologically, but they fail to mention the pyelographic deformities occurring as a result of these tumors. Beeler and Kirklin (2), in a significant discussion of roentgen findings accompanying carcinoma of the pancreas, emphasize the gastrointestinal abnormalities but make no reference to roentgen signs which may be produced by lesions of the body and tail of the gland. Abeshouse (1) has also noted that carcinoma of the pancreas may produce demonstrable defects in the mucosal pattern of the stomach or pressure on the retroperitoneal portion of the duodenum or the transverse colon. Such defects would naturally depend upon the exact location of the pancreatic lesion and in our experience might not be detected as early as those seen on urography.

Stone (8) and Ormond, Wadsworth, and Morley (6) state that pancreatic cysts with peripancreatitis may become attached to the kidney and be confused with renal tumor. Yates (10) found that masses in the liver flatten and deform the right kidney if there is fixation of the nephric and perinephric tissues. Poppel (7) calls attention to the impairment of renal function which may result from compression of blood vessels and also to the direct compression of the kidney mass, with its obvious implications. We do not believe that such fixation is necessary for the detection of pancreatic mass lesions. The clue, in our cases, was first seen on the supine films of the excretory urographic study. The renal parenchymal shadow is slightly broadened and occasionally elongated, the calyces appear stretched out and spindle-shaped without displacement, obstruction, or amputation; the renal pelvis shows varying degrees of compression deformity; the proximal ureter may be displaced posteriorly or laterally. Actual posterior displacement of the renal parenchymal shadow is not always seen but may sometimes be identified in the lateral pyelogram. If the kidney is not fixed by the pancreatic mass, the evidences of compression will be lost when the patient is placed in the erect posture. Retrograde pyelography, used as a supplementary procedure, may produce defects similar to those demonstrated in the excretory study, although care must be taken not to overdistend the pelvis and calyces and in so doing obliterate the signs of minimal compression. In every instance, the patient should be carefully prepared for the roentgen study and the films should be of such quality as to allow adequate evaluation of the renal and perinephric soft tissues.

The topographic anatomy of the pancreas and left kidney will help to explain the mechanism by which pressure effects are produced (Fig. 1). The body and tail of the pancreas lie obliquely over the middle or upper pole of the left kidney when the patient is in the supine position. Tumors and cysts of the body and tail produce a relatively immobile mass, which is seldom palpable or ballotable. While we agree with Abeshouse (1) that these tumors grow in the line of least resistance, that is, toward the abdominal cavity, it is also our opinion that they are frequently under the costal cage and by their weight alone, or by direct or indirect pressure, may produce the roentgen signs to which we have called attention.

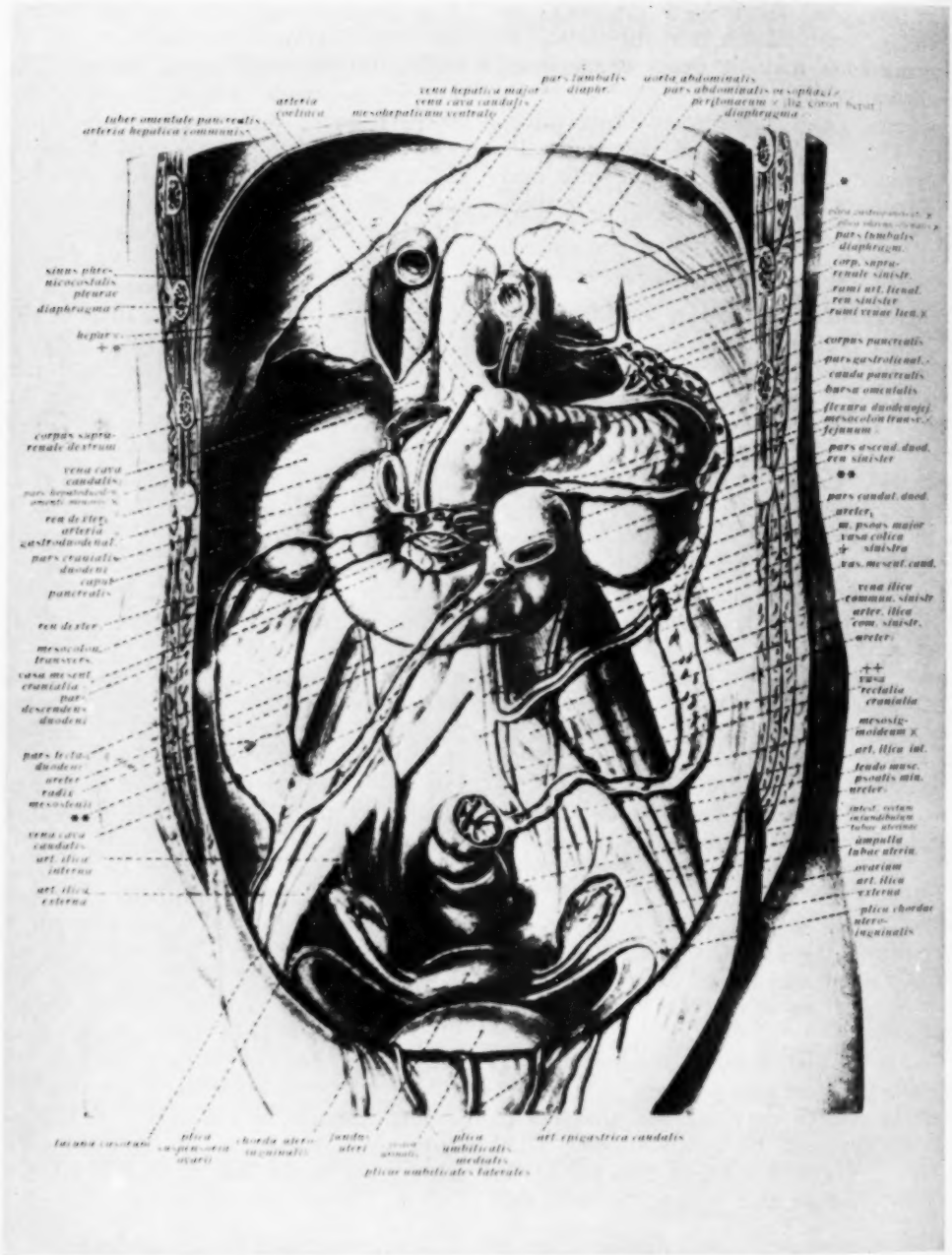

Fig. 1. Topographical anatomy of the pancreas and left kidney. Note that while the head of the pancreas is near a mid-line position, the body and tail lie directly over the left kidney and are more or less enclosed by the thoracic cage. These relations may vary somewhat with the relative position of the left kidney. In instances of renal compression the signs are more apparent when the patient is in the supine position. After Sobotta.

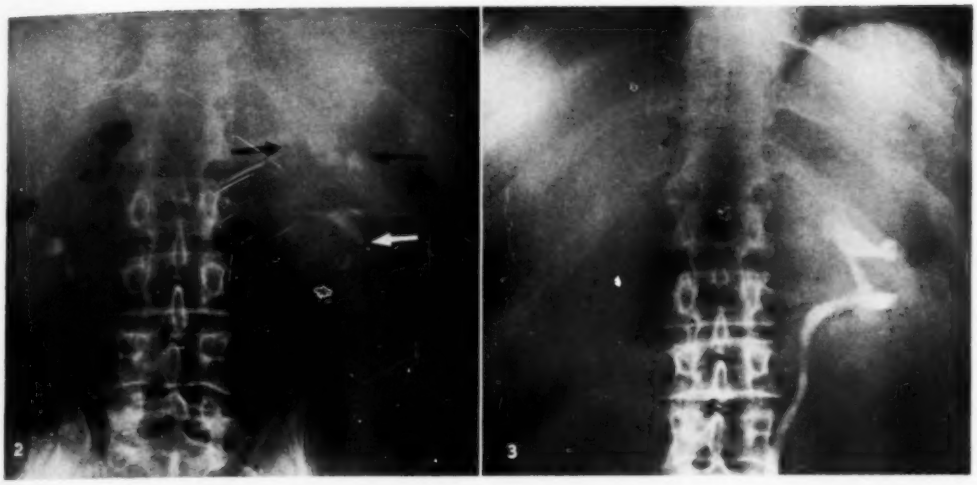

Fig. 2. Case I. Excretory urogram. Left kidney shows broad dilated and somewhat elongated upper polar calyces (black arrows). The calyces of the inferior pole maintain a normal and sharply cupped appearance (white arrow). This appearance could be mistaken for a renal tumor or abscess. The lesion was a carcinoma and retention cyst of the pancreas compressing and deforming the left kidney.

Fig. 3. Case I. Retrograde pyelogram. The pelvis is compressed and the wide dilated calyces are well seen.

CASE REPORTS

CASE I: C. O. B., a 51-year-old white man, was admitted with spasmodic pains in the left upper quadrant radiating to the left shoulder, of five months duration. There had been a weight loss of 19 lb.

Physical examination revealed a tender mass in the left upper quadrant of the abdomen, about the size of a plum.

Laboratory studies revealed a diabetic type of glucose tolerance curve; serum amylase, 155 Somogyi units; moderately elevated sedimentation rate; serum lipase, 2.5 units; marked diminution in duodenal trypsin.

The roentgen studies are reproduced in Figures 2, 3, and 4.

At laparotomy a large mass was found behind the stomach. The entire pancreas was hard and irregular. Between the pancreas and stomach was a pancreatic retention cyst containing 200 c.c. of amber fluid. The cyst and pancreas were adherent and fixed to the neighboring organs.

Histologically the cyst wall consisted of fibroblasts with scattered lymphocytes. The pancreas showed widespread invasion by scirrhous carcinoma. The tumor cells were arranged in small clumps and appeared to arise from ducts.

Death occurred about one year later, with severe backache and psychic disturbance.

Fig. 4. Case I. Lateral left pyelogram. All calyces are directed dorsally, and the kidney and upper ureter are displaced posteriorly (arrows).

CASE II: H. K., a 58-year-old white man, was admitted with bilateral lumbar backache, with radiation about the upper abdomen, of five months duration. The pain was worse when the patient was at rest. There had been a 40-lb. weight loss, with mild anorexia.

Findings on physical examination were: some pallor, muscular resistance in the epigastrium; a slightly enlarged, non-tender liver.

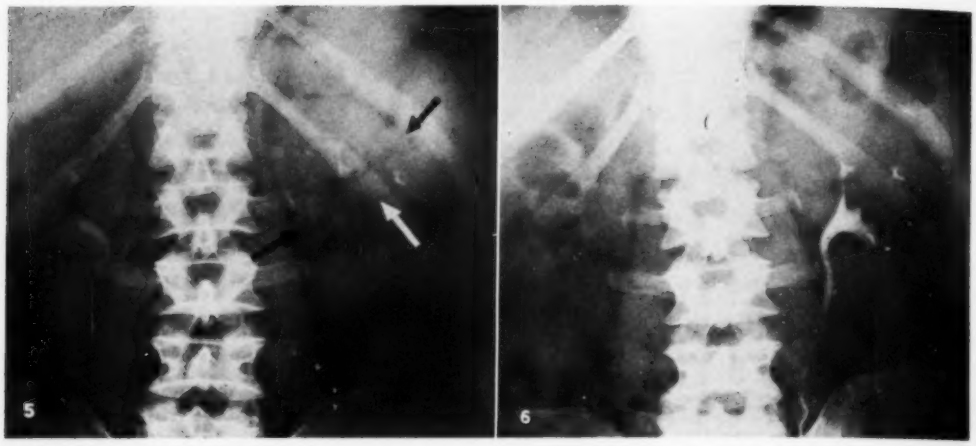

Fig. 5. Case II. Excretory urogram. The left renal parenchymal shadow is widened (black arrows). The coronal plane measures 8.5 cm. as compared to 6.5 cm. for the normal right kidney. The infundibular portions of the upper and middle major calyces are thin and elongated (white arrow). The minor calyces are normal. This appearance could be mistaken for an infiltrating renal lesion. Diagnosis: Carcinoma of the body and tail of the pancreas compressing the left kidney.

Fig. 6. Case II. Left retrograde pyelogram. The findings are similar to those in Fig. 3 except that the renal pelvis is now slightly overfilled and its true physiological size is not indicated. The minimal signs may thus be overlooked on this film.

Fig. 7. Case III. Excretory urogram, retouched to show the broad left kidney with elongated and spindle-shaped calyces. The minor calyces maintain their typical cupping. The right kidney is normal. Laparotomy showed carcinoma of the body and tail of the pancreas.

Laboratory studies revealed a mild normocytic anemia; elevated sedimentation rate; serum amylase, 39 Somogyi units; serum lipase, 0.5 units. The duodenal trypsin content was normal.

Roentgenograms are reproduced in Figures 5 and 6. During the patient's hospital stay thrombophlebitis of the right upper extremity developed.

At laparotomy a large, nodular, hard mass, 10 × 6 × 4 cm., was found retroperitoneally, involving mainly the body and tail of the pancreas, though the head also contained a small nodule. In the mesentery were many small nodules. The gallbladder was distended due to a nodule in the region of the ampulla of Vater.

Histologic section showed normal pancreas, with a spherical mass consisting of dense fibrous tissue and masses of adenocarcinoma. The tumor cells were small and cuboidal, forming small acini consistent with pancreatic origin.

The patient died several months later.

CASE III: S. S., a 61-year-old white man, was admitted to the hospital with abdominal pain of three months duration. The pain was severe, intermittent, originating in the upper abdomen and radiating over the entire abdomen and to the back in a radicular fashion. There had been an 8-lb. weight loss but no loss of appetite.

Physical findings were not significant.

Laboratory studies included: normal blood count; fasting blood sugar 95 mg. per c.c.; stools positive for neutral fat; serum amylase, 65 Somogyi units; sedimentation rate slightly elevated; serum lipase, 1.4 units. Duodenal drainage showed a normal trypsin level.

The roentgen findings were as shown in Figure 7.

A mass the size of a man's fist was found in the body and tail of the pancreas, on laparotomy. It was firm, hard, fixed, and infiltrating the splenic vessels. Several hard nodules were present in the mesentery.

Histologic section showed fibro-adipose tissue widely invaded by carcinoma. The tumor cells were small and cuboidal, with homogeneous cytoplasm and large basophilic nuclei.

CASE IV: N. T., a 61-year-old white woman, was admitted with dull soreness throughout the upper abdomen. For three years she had experienced malaise, muscle aches, fever to 101.3°, and gas and nausea after meals. There had been a 9-lb. weight loss in three months.

Physical examination revealed palpable abdominal masses and multiple thrombophlebitis of the extremities.

Fig. 8. Case IV. Excretory urogram. The left pyelogram shows elongation involving particularly the superior major calyx (white arrow). The renal pelvis is small (black arrow). The minor calyces are sharply cupped. The right kidney is normal. Autopsy showed carcinoma of pancreas.

Laboratory studies showed a mild anemia, cephalin flocculation, 2 plus; thymol turbidity, 3 units; bromsulfthalein excretion test (5 mg./kg.), 20 per cent retention in forty-five minutes; fasting blood sugar, 109 mg. per cent.

A gastrointestinal roentgen series was at first normal but two months later showed a large liver. The urogram is reproduced in Figure 8.

Laparotomy revealed a nodular mass involving the entire pancreas, approximately the size of a grapefruit, with metastases to the liver and omentum. Histologically this was found to be undifferentiated adenocarcinoma.

Death was due to carcinomatosis.

CASE V: F. B., a 59-year-old white woman, complained of constant backache, weakness, and continued weight loss. Eight weeks previously she had undergone a total hysterectomy for carcinoma of the fundus. A gastrointestinal series at that time was negative, but the patient had severe anemia and a markedly increased sedimentation rate.

Physical examination revealed a palpable mass in the left upper abdomen, hard and extending to the umbilicus.

Fig. 9. Case V. Excretory urogram. A faint soft-tissue density is seen over the left upper iliopsoas muscle. The left kidney and upper ureter are displaced laterally. Renal pelvis and calyces are morphologically normal. Exploratory laparotomy demonstrated a firm nodular mass in the left retroperitoneal space, probably primary in the body of the pancreas. Histologic diagnosis: Carcinoma of the pancreas.

Laboratory findings were: hemoglobin, 42 per cent; red cell count 2,530,000; white cells 18,850, with 92 per cent polymorphonuclears and 8 per cent lymphocytes; Westergren sedimentation rate 95 mm. in one hour. The urine contained 6 to 8 white blood cells and on culture showed the paracolon bacillus.

The findings on excretory urography were as shown in Figure 9.

Laparotomy revealed a firm nodular mass in a left retroperitoneal position, which was inoperable.

Biopsy diagnosis: Carcinoma, probably primary in the pancreas.

CASE VI. *First Admission:* V. L. G., a thirty-nine-year-old white woman, was admitted wth severe back pain of a week duration. The pain was described as beginning in the mid-lumbar region and radiating to the left costovertebral angle. There were intolerance to fatty foods, flatulence, heartburn, and moderate constipation, but no loss of weight.

Physical examination showed pronounced tenderness in the left costovertebral angle and over the entire anterior abdomen. No masses were palpable. The clinical impression was pyelonephritis, and the patient was discharged.

The findings on urinalysis were: albumin, 4 plus; coarse and firmly granular casts; 6 to 9 white blood cells and 3 to 4 red blood cells per high-power field. There was a mild normocytic anemia.

Second Admission: The patient was re-admitted eight months later, with continued pain in the left

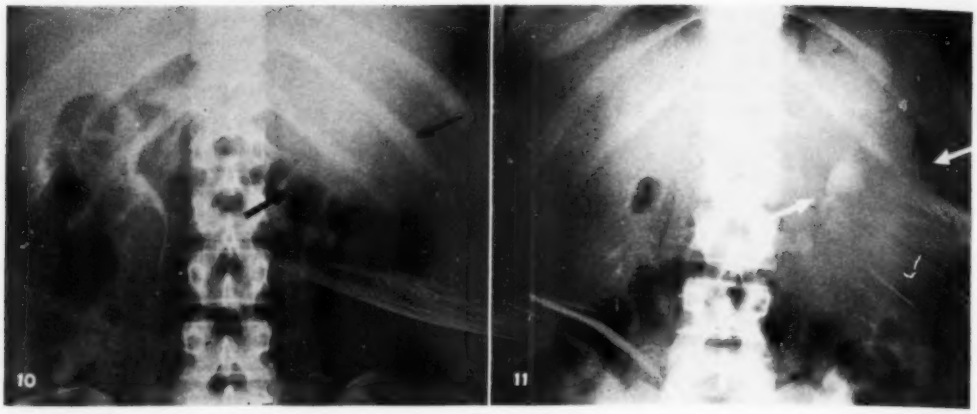

Fig. 10. Case VI. Excretory urogram. A somewhat circumscribed soft-tissue mass is discernible in the left upper abdomen. The supine film at twenty minutes shows a normal right pyelogram and an abnormal left pyelogram. The left kidney shadow is enlarged slightly (black arrows). The medium is not well retained in the calyces and the left renal pelvis.

Fig. 11. Case VI. Excretory urogram. The erect film at twenty-five minutes shows better filling of the pelvis as the extrinsic pressure is partially relieved. The patient had an endometrial type cyst involving the body of the pancreas. The white arrows show the width of the renal shadow.

abdomen, accentuated by menstruation and by urination. Gastrointestinal symptoms were as before, but there had been no appreciable weight loss. No abdominal masses were palpated but the entire abdomen was tender.

Urinalysis showed 3 plus albumin. The complete blood count was normal. The sedimentation rate was moderately elevated.

A gastrointestinal roentgen series disclosed displacement of the stomach to the right and anteriorly by an extrinsic mass. Pyelograms are reproduced in Figures 10 and 11.

Operation consisted in partial removal of a cystic mass with its base in the region of the tail of the pancreas. It contained about one liter of turbid brownish liquid.

Histologic sections showed a dense fibrous-walled pancreatic cyst with inclusions of normal pancreatic tissue in the wall. The inner portion consisted of chronic inflammatory tissue, and one part was lined by stroma and glands of endometrial or ovarian type.

Diagnosis: Pancreatic cyst, endometrial type.

COMMENT AND SUMMARY

It has been our purpose to present radiological evidence which will corroborate clinical findings in patients with disease of the body and/or tail of the pancreas. It must be emphasized that the roentgen evidence is supplementary to the clinical picture. Early roentgen signs are best observed in the excretory urogram and careful attention to the renal parenchymal soft-tissue shadow may lead to the recognition of the other positive signs in the calyces, pelvis, or ureter. Of 6 cases presented, 2 are of especial clinical interest, one (Case I) a benign cyst with carcinoma of the body and one (Case VI) an endometrial cyst.

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SUMARIO

La Pielografía para el Diagnóstico de las Lesiones del Cuerpo y de la Cola del Páncreas

En algunos enfermos que no revelaban ningún otro signo de la localización de su enfermedad, pudieron descubrirse lesiones masivas en el cuerpo del páncreas por medio de alteraciones observables en el pielograma del lado izquierdo. Preséntanse 6 de esos casos, comprendiendo carcinoma, quiste de retención y quiste benigno.

Hay que interpretar los hallazgos roentgenológicos a la luz del cuadro clínico. Se observan mejor en los urogramas excretorios tomados con el paciente en decúbito supino. La sombra del parénquima renal aparece ligeramente ensanchada y a veces alargada; los cálices parecen dilatados y fusiformes, sin desplazamiento, oclusión o amputación. No se observa siempre verdadero desplazamiento posterior de la sombra del parénquima renal, pero a veces puede identificarse en el pielograma lateral.

Hyaluronidase in Intramuscular Excretory Urography[1]

HERBERT L. WARRES, M.D., and ALBERT C. KING, M.D.

INTRAMUSCULAR excretory urography (1, 7) is one of the simpler and easier methods of studying the upper urinary tract in children. With the discovery of hyaluronidase (6, 8), the "spreading factor," extravascular administration of solutions has been facilitated (5). Several articles have appeared concerning the use of hyaluronidase in subcutaneous excretory urography (2, 3, 10). Since the technic of intramuscular is less difficult than that of subcutaneous urography (9, 11), the effect of hyaluronidase on the rate of absorption of Diodrast and Neo-Iopax administered intramuscularly was tested clinically.

TECHNIC

Into one buttock we injected either Diodrast 35 per cent or Neo-Iopax 50 per cent[2] in amounts varying from 6 to 10 c.c., plus 1 c.c. of 2 per cent procaine solution. Into the other buttock we injected the same mixture, to which had been added hyaluronidase in quantities from 150 to 750 TRU (turbidity reducing units). Thus each patient acted as his own control. Nine patients were tested in this manner.

In 9 others, the hyaluronidase was not mixed directly with the solution of the medium and procaine but was first dissolved in 2 c.c. of normal saline and injected into the buttock. Then, without moving the needle, the medium-procaine solution was administered. Three different brands of hyaluronidase were used.[3]

The patients were all children, ranging from one to nine years of age. Each was skin-tested for sensitivity to the medium (Diodrast and Neo-Iopax), hyaluronidase, and procaine. In no instance was any sensitivity found.

Roentgenograms were taken at ten-to twenty-minute intervals. In the earlier cases, they were obtained up to four hours after administration of the contrast medium. The optimum times were found to be twenty, forty, and sixty minutes.

The films not only outlined the urinary tract, but also enabled us to compare the rate of absorption of the medium with and without hyaluronidase in the same patient. Hyaluronidase in no case increased the rate of absorption and frequently delayed it. Residual soreness, though minimal, was more apt to occur in the buttock receiving the hyaluronidase-medium-procaine solution.

DISCUSSION

There is little doubt that hyaluronidase facilitates the diffusion of isotonic electrolytic solutions. The assumption that the accelerated rate of diffusion of introduced fluids means that they are also absorbed more rapidly has been questioned (4, 12).

It has been shown that isotonic sodium chloride is more rapidly absorbed when given by hypodermoclysis if hyaluronidase is used. However, isotonic glucose solution is merely diffused over a greater area (4). The use of hyaluronidase does not obviate the necessity of equilibration between the glucose solution and the body fluids. It has been concluded that hypodermoclysis with solutions containing large molecules is a potentially dangerous procedure.

We have had no experience with hyaluronidase in subcutaneous excretory urography. Using this agent in intramuscular urography apparently is disadvantageous. In pediatric urography we find

[1] From the Departments of Urology and Radiology, The Medical & Surgical Clinic, Laredo, Texas. Accepted for publication in October 1953.

[2] Neo-Iopax was supplied through the courtesy of the Schering Corporation.

[3] Hyaluronidase was supplied by the Schering Corporation; Alidase by G. D. Searle & Co.; Wydase by Wyeth, Inc.

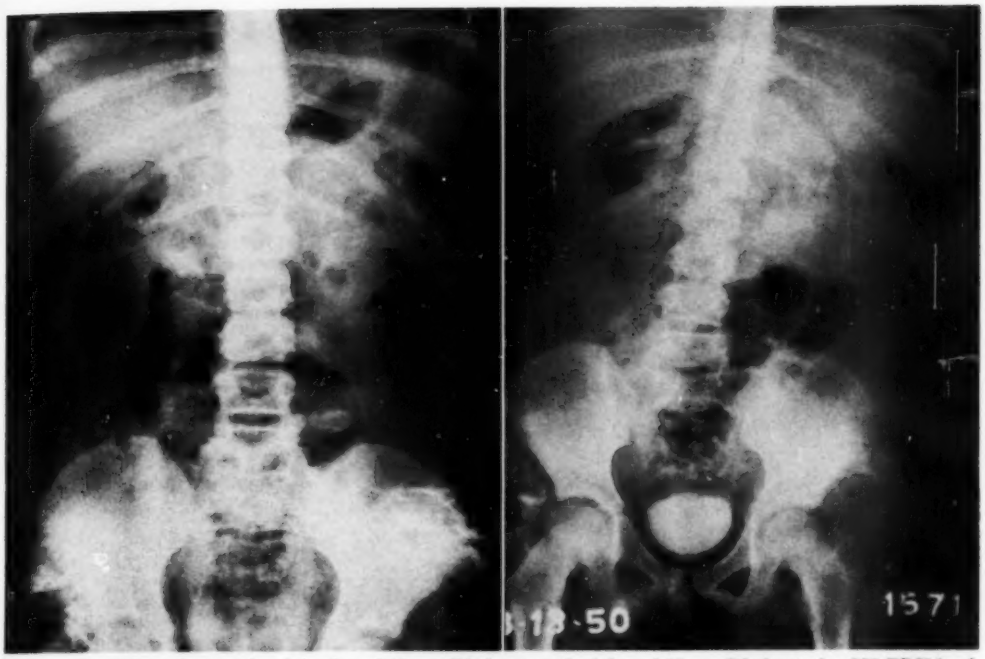

Fig. 1. A. Fifty minutes after injection of 10 c.c. Diodrast on the left and 10 c.c. Diodrast plus 250 TRU hyaluronidase on right.
B. Two and one-half hours after injection. The roentgenogram shows slower absorption on the right.

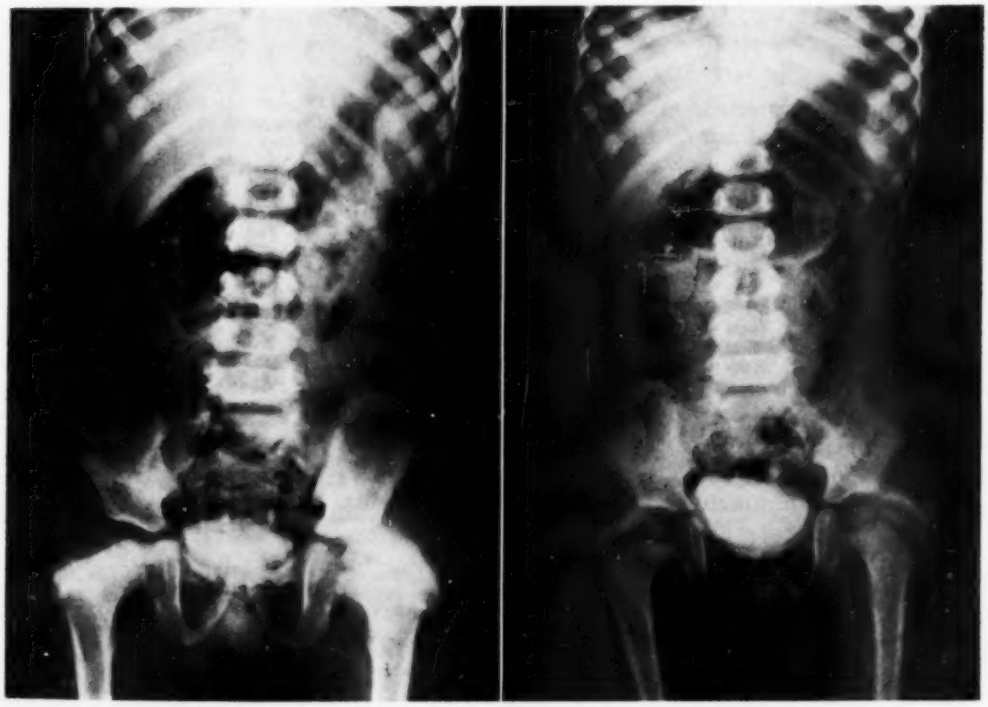

Fig. 2. A. Thirty-five minutes after injection of 7 c.c. Neo-Iopax on the left and 500 TRU hyaluronidase followed by 7 c.c. Neo-Iopax on the right.
B. One and one-half hours after injection. Same rate of absorption bilaterally.

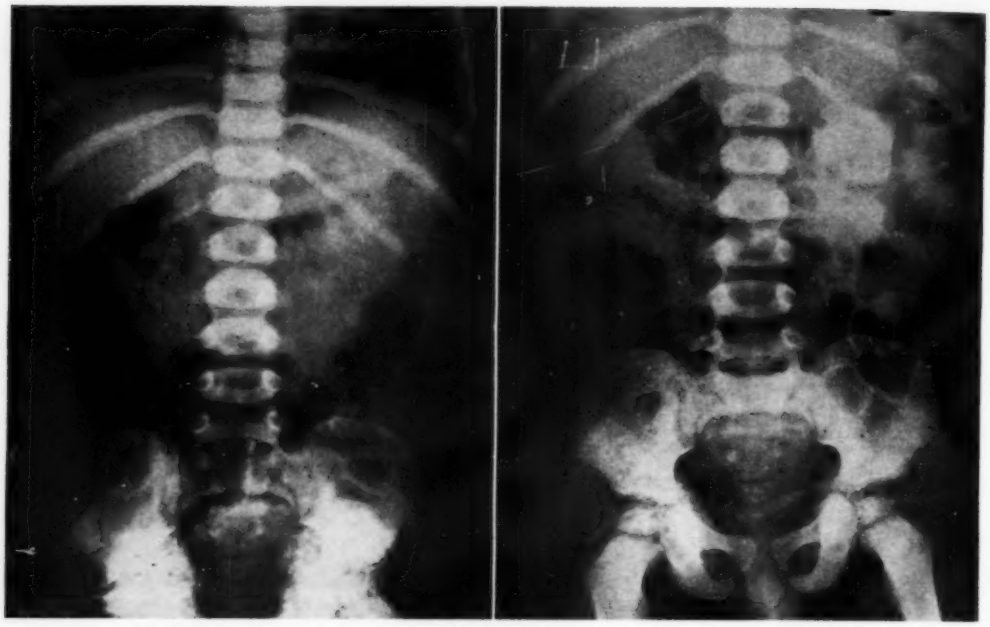

Fig. 3. A. Twenty minutes after injection of 7 c.c. Diodrast on the left and 500 TRU hyaluronidase followed by 7 c.c. Diodrast on the right.
B. One and one-half hours after injection. Slower rate of absorption on right. This patient had right renal agenesis and left hydronephrosis secondary to a congenital ureteropelvic stricture.

the intramuscular route more feasible than the intravenous, and our films are equally interpretable. Only minimal reactions have been seen to date.

CONCLUSIONS

1. Hyaluronidase does not facilitate the absorption of Diodrast 35 per cent or Neo-Iopax 50 per cent administered intramuscularly.

2. Diodrast 35 per cent is slightly superior to Neo-Iopax 50 per cent for intramuscular urography.

3. Neo-Iopax 50 per cent may be safely given intramuscularly.

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SUMARIO

La Hialuronidasa en la Urografía Intramuscular

La urografía excretoria intramuscular ha resultado ser uno de los métodos más sencillos y fáciles para el estudio de la porción superior del aparato urinario en los niños. Se ejecutaron experimentos clínicos para determinar el efecto de la hialuronidasa sobre la velocidad de la absorción del Diodrasto y del Neo-Iopax administrados por dicha vía. En 9 niños se inyectó en una nalga una mezcla del medio de contraste y de procaína y en la otra una mezcla semejante a la cual se había agregado hialuronidasa. En otros 9 niños, no se mezcló la hialuronidasa con el medio sino que se inyectó (en solución salina) antes de la inyección del medio y de la procaína. Las radiografías obtenidas a plazos revelaron que la hialuronidasa no facilitaba la absorción ni del Diodrasto ni del Neo-Iopax.

Hand-Operated Barium Pump Assembly for Examination of the Colon[1]

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Los Angeles, Calif.

THE PUMP SHOWN in Figures 1 and 2 is used in double-contrast studies of the colon as a booster for thick barium.

The pump itself consists of a hand crank (A) and rubber blades on a steel shaft (B) that rotate in a plastic cavity (C). The plastic cavity has an inlet (D) and outlet (E), with rubber tubing connections. The cavity is closed by a screw-type plastic cap (F) sealed by a rubber ring gasket. On one surface of the plastic cavity there is a raised flat area. When a blade passes over this raised area it is bent backward, increasing the space between it and the blade ahead. Increasing the space between the blades creates a suction filling the space with barium. The backward bent blade decreases the space between the bent blade and the one following, forcing the barium through the outlet.

This pump has several desirable features. It is easily taken apart for cleaning. The flow of barium is controlled by the rate of rotation, and stopping the pump stops the flow. This is extremely important, for the quality of the air-contrast study is largely dependent upon introducing an exact amount of barium. The pump does not build up a back pressure against resistance to the flow such as might be encountered in bowel obstruction, or produced by a kinking in the rubber tubing or by other causes. A minimal resistance to the flow results in a bending of all the rubber blades with no flow, making the pump completely safe.

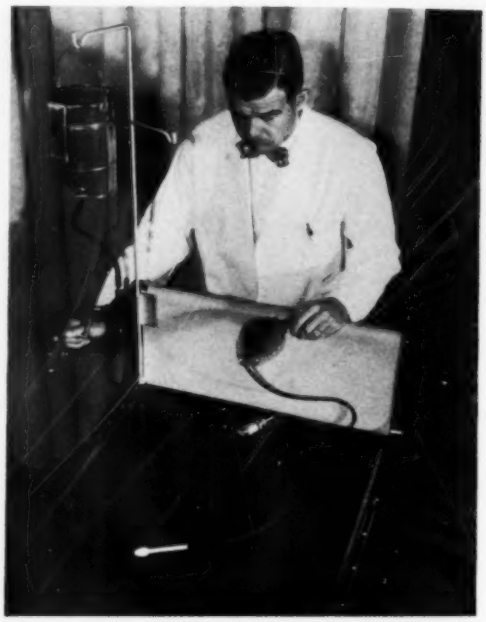

Figure 1

COMBINED PUMP AND ENEMA CAN STANDARD BRACKET

The barium pump described above is conveniently operated when fixed by a bracket to the left-hand side of the x-ray table footboard. It is also desirable to suspend the enema can from the footboard (Fig. 1). Therefore, a combined pump and enema can bracket was designed which fits all makes of x-ray tables. The bracket is mounted permanently to the footboard, but the pump and standard can be removed when not in use. The bracket does not interfere in any way with the operation of the table.

The combined pump and enema can standard bracket consists of a 3/8-inch thin-wall tubing (I) (Fig. 2), with a thin metal band welded to the ends. The bands curve around the footboard and tighten behind it with a turnbuckle. Also welded to the tube is a metal slot (G) of such size as to accommodate exactly the insertion of

[1] Presented as an exhibit at the Thirty-ninth Annual Meeting of the Radiological Society of North America, Chicago, Ill., Dec. 13-18, 1953. Accepted for publication in October 1953.

a metal plate (H). This plate is bolted to the pump; inserting the plate into the slot fixes the pump to the permanently mounted bracket. Attaching and removing the pump can be accomplished in a matter of seconds. A 3/8-inch metal rod enema standard (K) was designed to be inserted

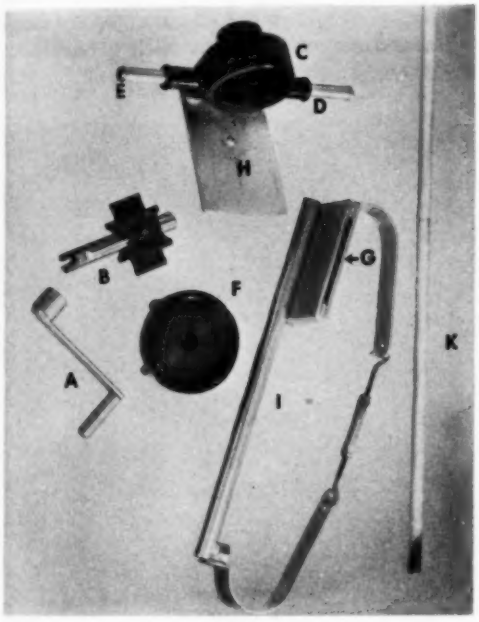

Figure 2

in the tube of the mounting bracket. This standard is usable for the conventional barium enema examination as well as the double-contrast study with thick barium.

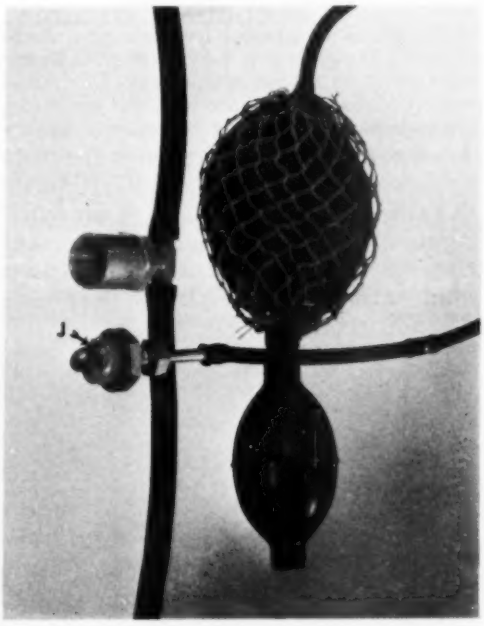

Figure 3

A T LOW-PRESSURE CHECK VALVE

The T low-pressure check valve (Fig. 3) is an added convenience. With a T in place in the tubing, air can be added at will and the check valve prevents the barium from entering the Weber insufflator. The valve is a flapper type (J) with a neoprene seat and the flap closes by spring tension.

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SUMARIO

Juego de Bomba de Bario Impulsado a Mano para el Examen del Colon

Descríbese un juego de bomba para empleo en los estudios a doble contraste del colon, que utilizan una mezcla espesa de bario.

El juego consta de la bomba reproducida en los grabados (Figs. 1 y 2) y de una agarradera que sostiene el depósito del líquido para enema, y que va a asegurarse a la mesa del aparato de rayos X. Otra conveniencia consiste en una válvula de retención a presión baja, que también aparece reproducida (Fig. 3).

Cerebellar Sarcoma with Bone Metastases[1]

WALTER H. KEHLER, M.D.,[2] and ERWIN BECK, M.D.[3]

INVASION OF adjoining structures and/or metastasis to other organs of the body are cardinal features of a malignant growth. In brain tumors involvement of surrounding tissue is a common surgical finding but metastases are rare. Distant metastasis from intracranial neoplasms was first reported by Klebs (7) in 1889, as cited by Jurow (6), who reports an additional case of his own. Jurow also cites a case reported by Lindner (8) in 1902. All 3 tumors were classified as endothelioma. In 2 of the cases there were metastases to the lung, and in 1 to the bladder. The case of Cushing and Eisenhardt (2), coming to autopsy after seventeen operations for recurrent meningioma, showed a solitary metastasis in the right upper lung. A report from the Records of the Massachusetts General Hospital (9) in 1938 describes a tumor found at necropsy to be a fibrosarcoma of the dura with generalized metastases to the bones, lungs, and adrenals. Other reported cases have revealed metastatic lesions in the spinal cord (1), regional lymph nodes (4, 5) lumbar spine and pelvis (10, 11), mediastinum (12), liver, and abdominal lymph nodes (11).

In all, there are but 10 cases reported in the literature of extradural metastases in adults from proved intracranial neoplasms, and only 3 with metastasis to bone.

Fig. 1. Roentgenogram (March 27, 1950), showing a normal lumbar spine and pelvis.
Fig. 2. Roentgenogram (Feb. 20, 1951) showing extensive osteoblastic changes in the pelvis and lumbar spine due to metastases.

[1] From the Radiological Service, Veterans Administration Hospital, Aspinwall, Penna., and the Department of Medicine and Surgery, University of Pittsburgh School of Medicine. Presented at the 37th Annual Meeting of the Pennsylvania Radiological Society, Bedford, Penna., May 16–17, 1952. Accepted for publication in January 1954.

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[3] Pittsburgh, Penna. Attending Radiologist, Veterans Administration Hospital, Aspinwall, Penna.

CASE REPORT

L. P., a 28-year-old white male, was admitted to the Veterans Hospital, Aspinwall, June 3, 1948. Occipital headaches of three months duration, with vomiting, weakness, and staggering gait, were the predominating symptoms. Examination disclosed nystagmus, unequal pupils, and blurring of the optic disk margins. Neurologic findings were a positive Romberg sign and astereognosis of the left hand. Roentgenograms of the skull and chest were negative. Spinal fluid studies showed a pressure of 300 mm., manometrically, and 62 mg. protein per 100 c.c.

Following admission, the patient became stuporous, with a rapid fall of pulse and respiratory rates. Ventricular drainage with a Frazier T-cannula inserted through a burr hole in the right occipitoparietal region afforded temporary relief. A ventriculogram revealed moderate dilatation of the lateral and third ventricles. Two cubic centimeters of phenolsulfonphthalein injected into the ventricular system failed to appear in the spinal fluid in forty-five minutes. It was decided that the patient had an obstructive hydrocephalus caused by a lesion in the posterior fossa.

A suboccipital craniotomy was performed eight days after admission, and extensive exploration of the posterior fossa failed to reveal evidence of tumor. The cerebellar tonsils herniated into the foramen magnum, and a decompression was carried out on the presumption of a tumor, surgically inaccessible, located high in the left cerebellar hemisphere. A tentative diagnosis of medulloblastoma was agreed upon, and it was decided that a course of roentgen therapy should be given. Fourteen days postoperatively, irradiation was begun. A tumor dose of 2,300 r was delivered in eighteen days to the posterior fossa. Improvement was rapid and the patient was discharged, asymptomatic, July 17, 1948.

In the latter part of February 1949, headaches recurred, with dizziness and vomiting. Speech was slurred and mental disorientation marked. There was past pointing and a positive Babinski. A second course of roentgen therapy was given, delivering a tumor dose of 2,700 r to the posterior fossa in thirty-seven days. Again improvement was rapid, and the patient was discharged, free of symptoms, in July 1949. In January 1950 (nine months after the second course of roentgen therapy), he showed no clinical evidence of recurrence and neurologic findings were essentially negative. He was working as an automobile salesman and driving his own car.

The patient was readmitted March 14, 1950, because of recurrence of symptoms, along with severe bilateral sciatic pains aggravated by walking or straining. Roentgenograms of the spine were

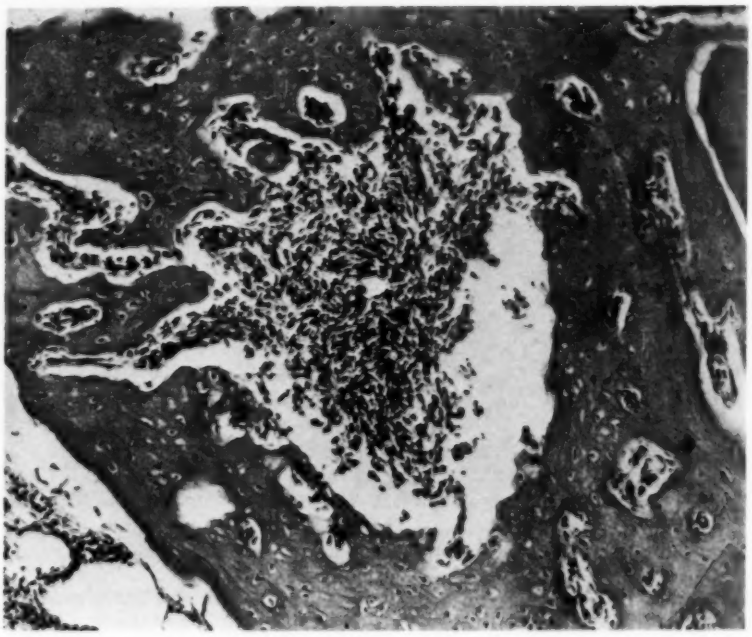

Fig. 3. Field typical of the widespread metastatic lesions of bone. The trabeculae of the marrow are markedly thickened and irregular. Hematoxylin and eosin.

negative (Fig. 1). It was felt that metastasis had occurred to the spinal cord and cauda equina. On March 28, 1950, a third course of roentgen therapy to the posterior fossa and spine was instituted. A tumor dose of 2,300 r was delivered to the posterior fossa in twenty-three days, 2,600 r (in air) were given to the entire spine, and 2,000 r (in air) to the sacrum. Complete remission of all symptoms followed, and the gait and reflexes became normal.

present ten months before. The metastatic involvement of bone resulted in a myelophthisic anemia, with depression of all the blood elements.

Because of threatening blindness and development of a complete paraplegia with sensory level at the umbilicus, a fifth course of roentgen therapy was started but was discontinued in the second week, when it became evident that no clinical improvement would be obtained.

Bone biopsy from the iliac crest (Fig. 3), performed

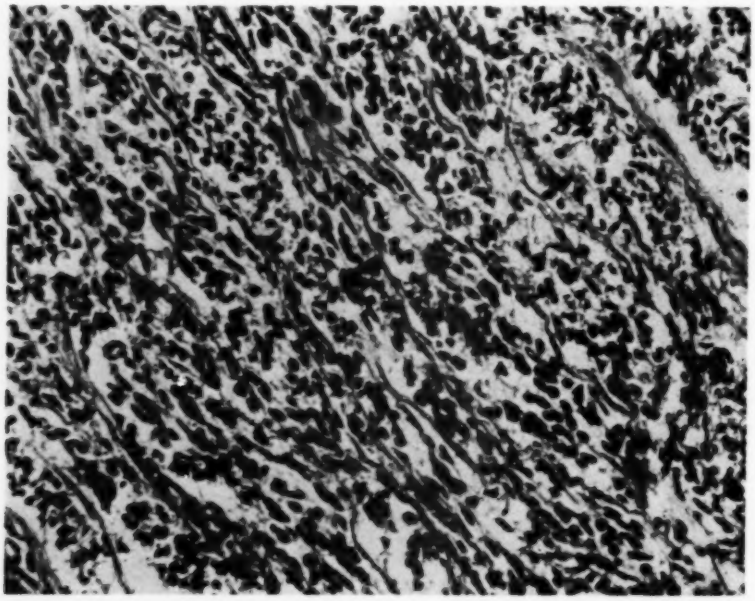

Fig. 4. Photomicrograph of the primary tumor. The pleomorphic nuclei are divided into bundles of thin strips of mature collagenous tissue. Hematoxylin and eosin.

The patient remained well until July 1950, when he began having occasional episodes of vomiting, headaches, and disturbance of equilibrium. He was admitted on Aug. 29, 1950, in critical condition, showing marked dysphagia and dysphonia, and a bilateral papilledema of 2–3 diopters. A fourth course of roentgen therapy was started Aug. 31, 1950, and a tumor dose of 2,600 r to the posterior fossa was given in twenty-one days. The clinical response was not as rapid as on previous occasions but improvement began during the third week of therapy, after which, recovery was once more progressive and complete. The patient was discharged, ambulatory and asymptomatic, on Oct. 26, 1950.

The final hospital admission was on Jan. 22, 1951. All of the signs and symptoms noted on earlier admissions were present. The blood count, which had previously been normal, now showed 2,200,000 red cells, 1,950 white cells, and 8.0 gm. of hemoglobin. A skeletal survey a few weeks later showed osteoblastic metastases (Fig. 2) in the lumbosacral spine, pelvis, thoracic spine, and ribs, which had not been

Feb. 18, 1951, showed highly undifferentiated tumor cells in the medullary spaces. Biopsy of a cervical node June 26, 1951, showed complete replacement by undifferentiated tumor tissue.

The severe pancytopenia remained uncontrolled despite numerous blood transfusions. Death occurred July 10, 1951, thirty-seven months after onset of symptoms.

Postmortem Examination: At autopsy, a well circumscribed tumor, the size of an egg, was found intimately associated with the leptomeninges of the left inferior and lateral aspect of the cerebellum. The tumor infiltrated irregularly along the leptomeninges and had even implanted itself on the dura covering the base of the skull. It invaded the sella turcica, completely surrounding the pituitary gland, and had invaded most of the foramina at the base of the skull. It was present in the ethmoidal but not in the sphenoidal sinuses. The operative defect in the occipital bone was also filled with tumor. The only gross changes on coronal sectioning of the brain were moderate edema and slight dilatation of

the ventricular system, especially the fourth ventricle. There were moderate enlargement of the cervical lymph nodes and widespread metastatic lesions in the vertebral bodies, ribs, pelvis, and sternum. The visceral organs were not involved.

Microscopic Examination: Histologically, the primary tumor (Fig. 4) was composed of undifferentiated fusiform and pleomorphic hyperchromatic nuclei with indefinite and poorly outlined, slightly fibrillar cytoplasm. These cells grew in small bundles, separated by thin collagen strands containing fibrocytic nuclei. Connective-tissue stains demonstrated this stroma and failed to stain the fibrillar processes of the malignant cells. In the metastatic lesions of bone and lymph node, the collagen stroma was absent. Here the only semblance of order was a tendency to form whorls in some fields. A few calcific psammoma bodies (Fig. 5) lay within the tumor that surrounded the pituitary gland. Invasion of the brain stem and cerebellum was perivascular (Fig. 6).

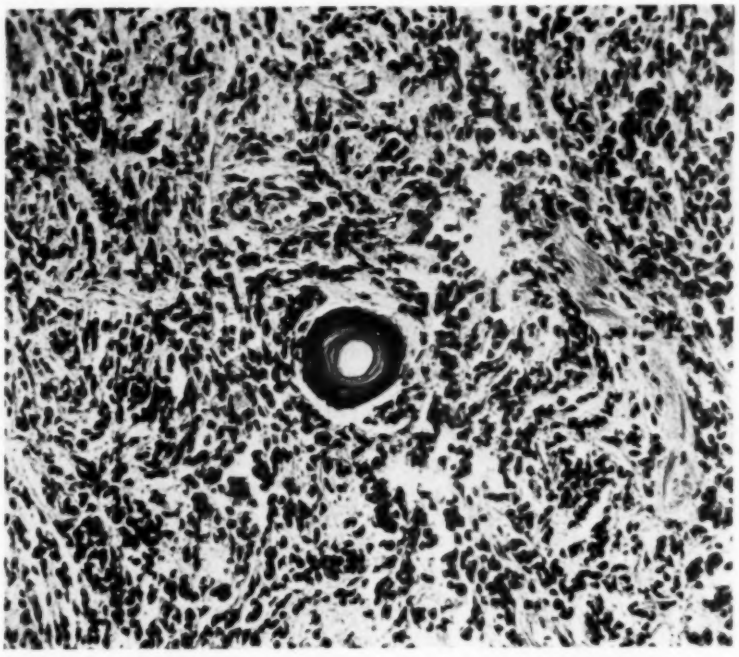

Fig. 5. A psammoma body in the tumor. This section was taken adjacent to the pituitary gland.

COMMENT

A case of cerebellar sarcoma, producing clinical manifestations commonly identified with cerebellar medulloblastoma, has been described. This undifferentiated tumor arose in the cerebellar meninges, spread along them, and implanted itself on the dura mater. It invaded the foramina of the skull and was present in the ethmoidal sinuses and cervical lymph nodes. It did not grow in lung or other visceral organs but had replaced about 50 per cent of the red bone marrow. The circumscribed nature of the primary mass grossly suggested that it had begun as an encapsulated tumor. If this is so, early surgical removal might have proved curative.

Freid and Davidoff (3) emphasize the mimicry of medulloblastoma by cerebellar sarcoma, both clinically and in the response to roentgen therapy.

CONCLUSION

A case of cerebellar sarcoma with lymph node and widespread bone metastases is presented. This type of lesion should be kept in mind by the radiologist when considering the differential diagnoses of osteoblastic metastases.

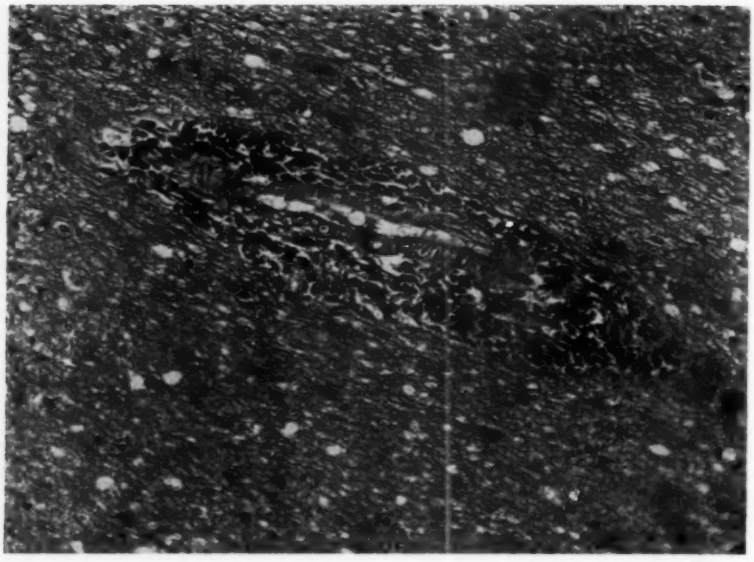

Fig. 6. Perivascular invasion of the brain substance in the cerebellum and brain stem. Hematoxylin and eosin.

Except for the production of extradural metastases, this entity is indistinguishable clinically and in its radiosensitivity from medulloblastoma.

There is evidence that early in its course this tumor may be encapsulated, making it amenable to complete surgical removal.

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SUMARIO

Sarcoma Cerebelar con Metástasis Oseas

Preséntase un caso de sarcoma originado en las meninges cerebelares, que se difundió a la duramadre y metastatizó ampliamente en los ganglios linfáticos y los huesos. El enfermo recibió cinco series de roentgenoterapia, con respuesta rápida en todas las ocasiones, excepto la última. Para dicha fecha, había aparecido una grave anemia mielopática a consecuencia de la invasión de la médula ósea, con depresión de todos los elementos sanguíneos.

En sus manifestaciones clínicas y respuesta a la irradiación, esos tumores se parecen mucho a los meduloblastomas.

EDITORIAL

The New Unit of Dose

As Count Korzybsky pointed out, language is the tool we think with, and a poor tool does poor work. For twenty-five years we have measured the x-ray dose in roentgens. The accuracy of the instruments available to measure it has led us at times into pedantry that compromised our sense of humor. Sometimes a patient comes, carrying a letter wherein it is stated that on March 2, 1953, he finished a course of treatments, 203 r per day to a total of 4,060 r, given at 197 kv. with 0.5 mm. Cu filter plus 1 mm. Al, h.v.l. 0.96 mm. Cu. Such precision! In his preoccupation with the third significant figure, the radiologist has forgotten to tell you the size of the field. If you are of a sarcastic turn of mind, which God forbid, you might write asking him whether treatment was at 50 cm. or 52. And whether the patient was treated on Sundays and on Washington's birthday. He wouldn't understand the rhetorical purpose of your demand for yet finer precision in the treatment details, and you would merely distract his attention from your only pertinent question, namely: were the roentgens of exposure measured in the bare x-ray beam, or does that 203 r "dose" refer to measurement made on the patient's skin?

When you are measuring the output of your tube, a unit of exposure fits your needs perfectly. But when you are planning and recording treatments—when your attention is on the patient and his skin and his tumor—then you think of the dose almost as if the tissue were soaking up dye and becoming redder the stronger the dye and the longer the application. A unit of exposure does not fit this concept well, but we have been using our roentgen under an unconscious perversion of its defined meaning so as to fit it to this practical need. In fact, we see in the official glossaries a tendency to redefine "dose" so that the concept will fit the unit, since the unit does not fit the concept.

Thinking becomes even muddier when to confusion of dose with exposure is added a further confusion of radiation dosage with drug dosage. *Exposure* is spread over an area. *Dose* is spread through a volume. The unit of volume is one cubic centimeter for radiation, but for a drug the unit is one patient. The confusion reveals itself most flagrantly when, for example, the letter of referral reports x-ray treatments of 12,000 r and it transpires that four fields were treated, 3,000 r to each.

In 1950, the International Committee agreed that treatment should be recorded in terms of the significant quantity, namely the specific energy absorption, for which the fundamental physical unit is the erg per gram. In 1953 the Committee adopted a practical unit, 100 ergs per gram, and named it the *rad*. It is so nearly equal, numerically, to the 93 ergs of energy that 1 c.c. of water will absorb from an exposure to 1 r, that the conversion factor is hardly important. The 7 per cent difference between 93 ergs and 100 ergs may often be smaller than the uncertainty as to the amount by which the exposure is augmented by scattering.

How well can we buckle down, now, and amend our bad habits to achieve routine recording of all our treatments in terms of rads in the tumor? And how soon shall we steel ourselves to leave out of our reports the minutiae concerning tube voltage, tube current, wave form, thickness of filter, and (usually) treatment distance? These, after all, are strictly domestic data which one needs for calculation of the dose to be achieved. And one needs to

record them, too, as a barrier against blunders and to answer future questions as to accuracy. But all that really affects the patient is the kind of treatment and the amount. Besides the pathological and clinical data, and the anatomical location and size of the field, the two significant measures that need to be told another radiologist are simply: *quality* in h.v.l. and *dose* in rads.

Let's have the radiologist make a private record of the factors on which he has calculated the dose. We have to trust his measurements and we ought to make him responsible for the calculations, too. No fair trying to unload this onto the reader (of the essay or the letter), saying, in effect: "Here are my data; if you don't believe I gave what I said I did, you can calculate it yourself." Let's give out, then, just the pertinent data about the dosage. In clinical x-ray therapy these are (1) quality (h.v.l.); (2) size and location of treatment fields; (3) fractionation and duration of treatment course; (4) absorbed dose (rads) in the tumor.

The absorbed dose in the skin is a private worry for the therapist and need not be confessed to the reader unless the essay concerns itself not with the response of disease to irradiation, but with the technic of getting the desired dose into the middle of the body. The same can usually be said of the target-skin distance. Protraction (r/min. during the application of the x-ray) is no longer thought to be critical by many therapists, so need not be reported unless the purpose of the research is in fact to evaluate its effect.

To reiterate: Let us report to others the four significant factors of x-ray treatment —area, quality, absorbed dose, and fractionation. Let us keep in our own records the measures on which the dose was calculated.

Maybe we ought to redesign the official treatment record form of the Radiological Society to make it easy to do the job that has to be done without wasting our effort and other people's time in giving a lot of stuff that can be dispensed with.

R. R. NEWELL, M.D.

SPRING EXAMINATIONS AMERICAN BOARD OF RADIOLOGY

The Spring 1955 examination by the American Board of Radiology will be held at the Palmer House, Chicago, during the week of May 22, 1955. The deadline for filing applications for this examination is Dec. 1, 1954.

Those candidates who will complete their required three years training by June 30, 1955, will be eligible to appear for the May examination. Those who will complete their training by Dec. 31, 1955, will be eligible for the Fall examination, to be held during the week of Dec. 4, 1955, also at the Palmer House, Chicago.

AMERICAN ROENTGEN RAY SOCIETY

The new officers of the American Roentgen Ray Society are: Joshua C. Dickinson, M.D., President; Paul C. Hodges, M.D., President-Elect; Frederic E. Templeton, M.D., 1st Vice-President; James M. Dell, Jr., M.D., 2d Vice-President; Barton R. Young, M.D., Secretary; Wendell G. Scott, M.D., Treasurer; Lawrence Reynolds, M.D., Editor.

W. Edward Chamberlain, M.D., is Chairman of the Executive Council, Edward L. Jenkinson, M.D., of the Finance Committee, Russell H. Morgan, M.D., of the Publication Committee, C. Allen Good, M.D., of the Scientific Exhibits Committee.

COLORADO RADIOLOGICAL SOCIETY

The following new officers were elected at the meeting of the Colorado Radiological Society, held, Sept. 17, 1954, at the Denver Athletic Club. President, R. Parker Allen, M.D., Denver; Vice-President, John H. Freed, M.D., Denver; Treasurer, Thomas J. Kennedy, M.D., Denver; Secretary, Stuart A. Patterson, M.D., Larimer County Hospital, Fort Collins.

PERUVIAN RADIOLOGICAL SOCIETY

Announcement has been received of the new Executive Committee of the Peruvian Radiological Society, for 1954–55. It includes Vicente Ubillús, M.D., President; Jorge de la Flor V., M.D., Vice-President; Amador Holgado V., M.D., Apartado 2306, Lima, Secretary General; José Luis Becerra, M.D., 2d Secretary; Napoleón Mattos, M.D., Treasurer; Luis Pinillos, M.D., Library Secretary.

REFRESHER COURSES

The Refresher Course announced for Friday, Dec. 10, by Dr. Raymond R. Lanier, should be headed Pediatric Urology X-ray Diagnosis instead of Pediatric X-ray Diagnosis.

Letter to the Editor

To the Editor of Radiology

DEAR DR. DOUB:

This letter is about units. I realize that units are strictly practical and there is no sin in using private units or coterie units. But if you do, there is the danger that other people won't know what you are talking about. And if you use ambiguous units there's danger that you yourself won't know what you are talking about. I think that *intensity* as a name for radiant flux density is coterie conversation, even though accepted in the National Research Council's Glossary of Terms in Nuclear Science. And I'm sure that *dose in roentgens* is ambiguous to boot.

It took George Laurence two years to make me understand that the roentgen, the international unit of quantity of x-ray, is a unit of exposure. I had been using it as a unit of dose, as most of my friends had been doing and continue to do. Radiologists want to determine and record what they give their patient—specifically what they give every cell of the tissue irradiated. *Erythema dose* was a unit fitted to our needs, except that we couldn't read the dose until two weeks after we'd given it. Also it wasn't readable very precisely. We turned to the physicists, who do measure things precisely. They were well convinced that they knew the physical effect that was pertinent, namely the ionization per unit volume. But they couldn't measure it. Would we settle for measuring the quantity of radiation? Yes, we would, and we did at Stockholm in 1927, on the promise that the unit would be tied to the ionization that we were interested in. And so we got the roentgen, which measures time integral of flux density evaluated according to its ability to ionize air.

Let us state a practical principle: If you can't measure what you wish to measure, you can at least measure what you *can* measure.

Now, a quarter of a century later, the shoe pinches on the other foot. We have learned to measure, indirectly, the energy absorption in irradiated matter (water or flesh); but above a few megavolts we find that it is quite impractical to measure the quantity of radiation in roentgens. So we are given a new unit, the *rad*, which measures specific energy absorption, no matter what the voltage, and for any kind of ionizing radiation.

We have now nicely distinguished units, one the *roentgen*, to measure what we throw at our patient, let him do with it what he will; the other, the *rad*, to measure what our patient gets out of it, whatever the form it comes in. This is all physics, of course, and has yet to be multiplied by relative biologic effect and modified by clinical judgment.

The moral is: It took a long, long time to come—will it be as long again before we learn to get the benefit of it?

That's really the whole of my message, but if you are willing, I'd like to chew on it a while longer.

Radiation is energy going from here to there. You can call it a flux. You can get your hands on it starting out, and again on its arrival, but while it's on its way it's just a nice manner of thinking. So we know it by what we do to it (starting) or by what it does to us (arriving).

If we are concerned with the amount of energy transported, the convention is to call it radiant flux, and the physicists have a set of sharply defined terms and symbols covering the quantitative aspects at the source and at the receiver. If the flux we're concerned with is light to see by, we call it luminous flux. There's a set of terms for this, too. Measurements of luminous flux are based on a standard source (the candle). If it's x-rays, we're concerned with, for medical purposes, we can call it roentgen flux. I invented terms for the quantitative aspects of roentgen flux to parallel some of those in use for luminous flux (Radiology **32**: 270, 1939). One was *plem*, the unit source. But this was long after we had ceased to record treatments in milliampere minutes with a given spark gap ("indirect dosimetry" we used to call it). We were very glad when the physicists fixed us up to measure roentgen flux, not at the source, but on arrival, by a specific effect (ionization of air).

Let us look at these three fluxes again. In radiant flux we might be interested in the total energy transferred, which would be measured in ergs or a convenient multiple (joule = 10^7 ergs or calorie = 4.2×10^7 ergs). This is the time integral of the flux. For light we're not aware of any accumulation; it has to keep on coming or we stop seeing. So we buy a lamp that takes in a given flux of energy (power, measured in watts) and gives out a promised luminous flux, measured in lumens.

But for x-rays we are concerned with the flux that passes through every cell and what it does to it, or, thinking of the skin surface, a lot of cells side by side. So we're thinking of the flux arriving on every unit of area, *i.e.* the flux density. And unlike light for seeing, but quite like light for photography, we are definitely interested in the accumulation. Our unit, therefore, is tailored to fit our needs. In essence, air is spread across the flux in a layer so thin that the flux is not appreciably less at the back than at the front. When the ions produced total a given number (about two billion) per cubic centimeter, no matter how many have recombined or how few still remain, we can turn the x-ray off and record 1 r. Note that, when we irradiate air this way in order to *measure* the x-ray, we put in charged plates to catch the ions before they have a chance to recombine. What our meter measures is electric charge or perhaps electric current. From this we count the ions (as a man in a mint might "count" silver blanks out of which to make dimes, by weighing a scoopful). And from the count of ions and the amount of air, we infer the roentgen flux to which each element of air has been exposed. The roentgen is a unit of exposure (time integral of roentgen flux density).

Photographers haven't got a named unit of exposure. They measure the luminous flux density with a meter, put the reading into a computing machine along with the maker's speed number for the film and their chosen stop number for the geometrical attenuation of the light when it shall go through the lens and reach the film. Then they read off, in seconds, the desired exposure time. And the only unit the photographer names is the last, *i.e.*, seconds, but he calls it "exposure" even though it measures duration.

The photographers have got along all right. I'm not worried about their future. They haven't any human lives on their conscience. So far, we radiologists have got along, too. But for the future I think we are not going even to get by without really understanding the difference between roentgens (exposure) and rads (absorbed dose).

Sincerely,

R. R. NEWELL, M.D.
Stanford University Hospitals
San Francisco, Calif.

Books Received

Books received are acknowledged under this heading, and such notice may be regarded as recognition of the courtesy of the sender. Reviews will be published in the interest of our readers and as space permits.

THE AUXILIARY HEART. By WILLIAM WALTER WASSON, M.D. A volume of 186 pages, with numerous illustrations including roentgenograms, photomicrographs, schematic drawings, and tables. Published by Charles C Thomas, Springfield, Ill., 1954. Price $10.50.

CLINICAL APPROACH TO JAUNDICE. By LEON SCHIFF, M.D., PH.D., Professor of Clinical Medicine, University of Cincinnati College of Medicine; Director, Gastric Laboratory, Cincinnati General Hospital. A monograph in American Lectures in Abdominal Viscera, edited by Lester R. Dragstedt, M.D., Chairman, Department of Surgery, University of Chicago, The School of Medicine, Chicago, Ill. A monograph of 114 pages, with 52 illustrations and 4 tables. Published by Charles C Thomas, Springfield, Ill., 1954. Price $3.75.

CHOLESTEATOMA OF THE MIDDLE EAR. A CLINICAL AND ROENTGENOLOGIC STUDY. Acta radiologica Supplement 111. By LARS WINDEREN AND

JOHANNES ZIMMER. From the Department of Otolaryngology, the University Hospital in Oslo (Head: Professor Odd Opheim, M.D.) and from the Department of Radiology, the University Hospital in Oslo (Head: Professor Torleif Dale, M.D.). A monograph of 120 pages, with 45 illustrations and 35 tables. Published by Acta radiologica, Stockholm 2, Sweden, 1954. Price Sw. Kr. 20:—

MALIGNANT TRANSFORMATION OF SQUAMOUS EPITHELIUM. A CYTOCHEMICAL STUDY WITH SPECIAL REFERENCE TO CYTOPLASMIC NUCLEIC ACIDS AND PROTEINS. Acta radiologica Supplement 112. By GUNNAR MOBERGER. From the Wallenberg Laboratory for Experimental Cytology at the Institute for Cell Research (Chief: Professor T. Caspersson, M.D.), Medical Nobel Institute, Karolinska Institutet, Stockholm, Sweden. A monograph of 108 pages, with 45 illustrations and 12 tables. Published by Acta radiologica, Stockholm 2, Sweden, 1954. Price Sw. Kr. 25:—

ROENTGEN EXAMINATION OF THE PROXIMAL FEMUR END IN CHILDREN AND ADOLESCENTS. A STANDARDIZED TECHNIQUE ALSO SUITABLE FOR DETERMINATION OF THE COLLUM-, ANTEVERSION-, AND EPIPHYSEAL ANGLES. A STUDY OF SLIPPED EPIPHYSIS AND COXA PLANA. Acta radiologica Supplement 110. By LARS BILLING. From the Orthopedic Clinic (Vanföreanstalten), Gothenburg (Head: E. Severin, M.D.) and from the Roentgen Department III of Sahlgrenska Sjukhuset, Gothenburg (Head: I. Wickbom, M.D.). A monograph of 80 pages, with 23 figures and 4 tables. Published by Acta radiologica, Stockholm 2, Sweden, 1954. Price Sw. Kr. 25:—

THE CAUSAL RELATIONSHIP BETWEEN BENIGN EPITHELIAL TUMORS AND ADENOCARCINOMA OF THE COLON AND RECTUM. Acta radiologica Supplement 113. By K. A. HULTBORN. From the Department of Surgery (Head: Professor John Hellström), Radiumhemmet (Head: Professor Sven Hultberg), and the Institute of Radiopathology (Head: Associate Professor Lars Santesson), Karolinska Sjukhuset, Stockholm, Sweden. A monograph of 72 pages, with 78 illustrations. Published by Acta radiologica, Stockholm 2, Sweden, 1954. Price Sw. Kr. 15:—

THE CONVENTIONAL ROENTGENOGRAM IN THE COMMONEST CONGENITAL MALFORMATIONS OF THE HEART AND GREAT VESSELS IN ADULTS AND JUVENILES. Acta radiologica Supplement 114. By GEORG-FREDRIK SALTZMAN. From the First Roentgen Department (Director: Gunnar Jönsson), Södersjukhuset, Stockholm, Sweden. A monograph of 60 pages, with 29 illustrations. Published by Acta radiologica, Stockholm 2, Sweden, 1954. Price Sw. Kr. 25:—

MEDICINA NUCLEARE. Introduzione alle applicazioni medico-biologiche della fisica nucleare. By ALDO PERUSSIA, with the collaboration of U. FACCHINI, E. GATTI, L. MALATESTA, C. SALVETTI, AND M. SILVESTRI. Prefaces by Professors G. Bolla, F. Perussia, and P. Rondoni. A volume of 878 pages, with 143 figures and 23 tables. Published by Il Pensiero Scientifico Editore, Rome, 1954.

LA LETTERATURA RADIOLOGICA ITALIANA. Volume VIII. Indice bibliografico dei lavori italiani di radiologia dal 1951 al 1953. By PROF. CARLO BIGNAMI AND PROF. CARLO PORTA. Preface by PROF. FELICE PERUSSIA. A volume of 178 pages. Published by Istituto per la diffusione di opere scientifiche, Milan, 1954. Price Lire 7,000.

Book Reviews

THE YEAR BOOK OF RADIOLOGY (1953–1954 YEAR BOOK SERIES). RADIOLOGIC DIAGNOSIS, edited by JOHN FLOYD HOLT, M.D., Associate Professor, Department of Roentgenology, University of Michigan, and FRED JENNER HODGES, M.D., Professor and Chairman, Department of Roentgenology, University of Michigan. RADIATION THERAPY, edited by HAROLD W. JACOX, M.D., Professor of Radiology, College of Physicians and Surgeons, Columbia University; Chief, Radiation Therapy Division, Radiologic Service, Presbyterian Hospital, New York City, and VINCENT P. COLLINS, M.D., Professor and Chairman, Department of Radiology, Baylor University, College of Medicine; Radiologist-in-chief, Jefferson Davis Hospital, Houston, Texas. A volume of 462 pages, with 399 figures. Published by The Year Book Publishers, Inc., 200 E. Illinois St., Chicago, Ill. Price $8.00.

The 1953–54 Year Book of Radiology is the twenty-second of this valuable series covering the advances in radiologic diagnosis and radiotherapy year by year through comprehensive abstracts of the literature. A comparison of the present volume with that of a decade ago is indicative of the enlarging scope of the specialty and some of its changing emphases. The greatly increased space devoted to cardiovascular radiography is a case in point in the Diagnostic Section and the radioisotope coverage in the Section on Radiation Therapy.

The bulk of the material, as is to be expected, is of American origin, though the British and Scandinavian literature has been well reviewed and there are scattered references to the French and Italian. The Dutch are represented by a single contribution and there are two abstracts from the *Schweizer medizinischer Wochenschrift*. The German and Latin-American literature seems to have been entirely neglected.

An interesting feature of the Radiation Therapy Section is a brief account of the International Con-

gress held in Copenhagen and of the visit to some of the leading European radiotherapy departments by one of the editors (Dr. Harold W. Jacox).

The arrangement of the material is good, and the editorial comments are brief and to the point. The inclusion of occasional references to related contributions, a practice long followed in RADIOLOGY, adds to the usefulness of the work.

MEDICAL PROGRESS, 1954. A REVIEW OF MEDICAL ADVANCES DURING 1953. Edited by MORRIS FISHBEIN, M.D. A volume of 345 pages. Published by The Blakiston Company, Inc., New York, N. Y., 1954. Price $5.00.

This volume comprises a series of reviews of medical progress during the year 1953. These are written by men competent in the various fields and show not only the accomplishments of the year but indicate the general trends for the future. The book will be of interest to those who wish to obtain an overall picture of recent developments in medicine. Radiology receives only cursory attention, in relation to other specialties, as Gastroenterology and Urology.

RADIOLOGIE CLINIQUE DE L'INTESTIN GRÊLE DE L'ADULTE ET DE L'ENFANT. (OCCLUSION AIGUE DE L'ADULTE EXCEPTÉE.) By P. PORCHER, Membre de l'Académie de Chirurgie, Radiologiste des Hôpitaux de Paris; P. BUFFARD, Radiologiste des Hôpitaux de Lyon; J. SAUVEGRAIN, Radiologiste des Hôpitaux de Paris. A volume of 618 pages, with 345 illustrations. Published by Masson & Cie, 120, Boulevard Saint-Germain, Paris (VI°), 1954. Price 5,000 fr.

This monograph presents in rather full detail the subject of clinical radiology as applied to the small bowel. The various methods of examining the bowel radiologically are described, and its anatomy and physiologic mechanisms are thoroughly discussed. Special consideration is given to small bowel studies in infants and children and to the diseases which are more commonly seen in these early periods of life. Metabolic diseases, various insufficiency diseases, allergies, infectious processes including tuberculosis and granulomatous conditions of non-specific nature, such as regional enteritis, are all included. The study of the ileocecal region is emphasized in a separate chapter.

The book is well illustrated with over 300 roentgenograms. Where some of the detail is lost in the positive prints, the authors have thoughtfully included small diagrammatic sketches to demonstrate the pathologic changes. Some of the figures have legends in French, but legends in English are also provided. An extensive bibliography is given at the end of each chapter.

The text is sound and can readily be recommended as a reference work on the roentgenologic diagnosis of small bowel diseases.

TRAITÉ TECHNIQUE DE TOMOGRAPHIE OSSEUSE. By ROBERT HERDNER. Préface by Professeur D. Petit-Dutaillis. A volume of 407 pages, with 338 illustrations. Published by Masson et Cie, Paris, 1953. Price 4,600 fr.

This fine work, obviously a labor of love, was written by a radiologist in private practice away from any great teaching center. This probably explains the overwhelming predominance of the anatomic over the pathologic in his illustrations. This is in no way a detraction, since he clearly demonstrates what can be accomplished in tomography of the skull and spine. Most of the volume deals with the skull and in reality supplements any work on its classic anatomy. For example, only by the tomographic method could such structures as the vidian, palatine, and optic canals be studied adequately.

The reviewer regards this work of value not so much for its objective presentations, as for the demonstration of what painstaking care can produce with the method and as a potent source of stimulation for others to carry on.

The printing, binding, and illustrations are excellent.

DIE OBJEKTIVE STEREOSKOPIE AN RÖNTGENBILDERN. EINE DIAGNOSTISCHE METHODE. By PROF. Dr. A. HASSELWANDER, Arlaching/Chiemsee. A monograph of 187 pages, with 125 illustrations. Published by Georg Thieme, Stuttgart, 1954. Distributed by Intercontinental Medical Book Corporation, New York, Price $6.40.

Starting as an anatomist, Doctor Hasselwander first utilized roentgen stereoscopy to reconstruct the body in its living state and thus correct misconceptions dependent upon conditions in the cadaver. The author's background colors this book on stereoscopy to the point that it is more a thesis than a text. The studies on the anatomic position of the diaphragm and the heart are original and academically quite interesting. Other inquiries directed at the size of the trachea and bronchi, at tooth relationships in terms of occlusion, and to foreign body localization seem only superficially applicable in present day radiology.

The single roentgenogram adequately provides two dimensions. Stereoscopic views are undoubtedly the best for obtaining the third dimension and certainly better than present attempts at geometric reconstruction. This monograph does outline the proper exposure of the films, the mathematics of stereoscopy, the details of viewing the two roentgenograms and the principles of both true and false stereoscopic vision. Modern research in fluoroscopic stereoscopy is discussed. There are, in addition, a few reproductions of models sculptured under stereoscopic guidance which, allowing for the awkwardness inherent in this procedure, seem adequate.

RADIOLOGICAL SOCIETIES: SECRETARIES AND MEETING DATES

Editor's Note: Secretaries of state and local radiological societies are requested to co-operate in keeping this section up-to-date by notifying the editor promptly of changes in officers and meeting dates.

RADIOLOGICAL SOCIETY OF NORTH AMERICA. *Secretary-Treasurer*, Donald S. Childs, M.D., 713 E. Genesee St., Syracuse 2, N. Y.

AMERICAN RADIUM SOCIETY. *Secretary*, Robert E. Fricke, M.D., Mayo Clinic, Rochester, Minn.

AMERICAN ROENTGEN RAY SOCIETY. *Secretary*, Barton R. Young, M.D., Germantown Hospital, Philadelphia 44, Penna.

AMERICAN COLLEGE OF RADIOLOGY. *Exec. Secretary*, William C. Stronach, 20 N. Wacker Dr., Chicago 6.

SECTION ON RADIOLOGY, A. M. A. *Secretary*, Paul C. Hodges, M.D., 950 East 59th St., Chicago 37.

Alabama

ALABAMA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, J. A. Meadows, Jr., M.D., Medical Arts Bldg., Birmingham 5.

Arizona

ARIZONA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, R. Lee Foster, M.D., 507 Professional Bldg., Phoenix. Annual meeting with State Medical Association; interim meeting in December.

Arkansas

ARKANSAS RADIOLOGICAL SOCIETY. *Secretary*, Joe A. Norton, M.D., 843 Donaghey Bldg., Little Rock. Meets every three months and at meeting of State Medical Society.

California

CALIFORNIA MEDICAL ASSOCIATION, SECTION ON RADIOLOGY. *Secretary*, H. R. Morris, M.D., 1027 D St., San Bernardino.

EAST BAY ROENTGEN SOCIETY. *Secretary*, Dan Tucker, M.D., 434 30th St., Oakland 9. Meets monthly, first Thursday, at Peralta Hospital.

LOS ANGELES RADIOLOGICAL SOCIETY. *Secretary*, Oscar Harvey, M.D., 3741 Stocker St., Los Angeles 8. Meets monthly, second Wednesday, Los Angeles County Medical Association Bldg.

NORTHERN CALIFORNIA RADIOLOGICAL CLUB. *Secretary*, H. B. Stewart, Jr., M.D., 2920 Capitol Ave., Sacramento. Meets last Monday of each month, September to May.

PACIFIC ROENTGEN SOCIETY. *Secretary*, L. Henry Garland, M.D., 450 Sutter St., San Francisco 8. Meets annually at time of California State Medical Association convention.

RADIOLOGICAL SOCIETY OF SOUTHERN CALIFORNIA. *Secretary-Treasurer*, George Jacobson, M.D., Box 146, 1200 N. State St., Los Angeles 33.

SAN DIEGO RADIOLOGICAL SOCIETY. *Secretary*, C. W. Bruner, M.D., 2456 Fourth Ave., San Diego 1. Meets first Wednesday of each month.

SAN FRANCISCO RADIOLOGICAL SOCIETY. *Secretary*, I. J. Miller, M.D., 2680 Ocean Ave., San Francisco 27. Meets quarterly, at the University Club.

SOUTH BAY RADIOLOGICAL SOCIETY. *Secretary*, Herbert R. Berman, M.D., 309 St. Claire Bldg., San Jose. Meets monthly, second Wednesday.

X-RAY STUDY CLUB OF SAN FRANCISCO. *Secretary*, Wm. W. Saunders, M.D., VA Hospital, San Francisco 21. Meets third Thursday at 7:45, Lane Hall, Stanford University Hospital.

Colorado

COLORADO RADIOLOGICAL SOCIETY. *Secretary*, Stuart A. Patterson, M.D., Larimer County Hospital, Fort Collins. Meets monthly, third Friday, at University of Colorado Medical Center or Denver Athletic Club.

Connecticut

CONNECTICUT STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY. *Secretary-Treasurer*, William A. Goodrich, M.D., 85 Jefferson St., Hartford 14. Meets bimonthly, second Wednesday.

District of Columbia

RADIOLOGICAL SECTION, DISTRICT OF COLUMBIA MEDICAL SOCIETY. *Secretary*, John A. Long, M.D., 1801 K St., N.W., Washington 6. Meets third Wednesday, January, March, May, and October, at 8:00 P.M., in Medical Society Library.

Florida

FLORIDA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, James T. Shelden, M.D., Box 1021, Lakeland. Meets in April and in October.

GREATER MIAMI RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Richard D. Shapiro, M.D., 541 Lincoln Road, Miami Beach. Meets monthly, third Wednesday, 8:00 P.M.

NORTH FLORIDA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Ivan Isaacs, M.D., 1645 San Marco Blvd., Jacksonville 7. Meets quarterly, March, June, September, and December.

Georgia

ATLANTA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Albert A. Rayle, Jr., M.D., 490 Peachtree St. Meets second Friday, September to May.

GEORGIA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Herbert M. Olnick, M.D., 417 Persons Bldg., Macon, Ga. Meets in November and at the annual meeting of the State Medical Association.

RICHMOND COUNTY RADIOLOGICAL SOCIETY. *Secretary*, Wm. F. Hamilton, Jr., M.D., University Hospital, Augusta. Meets first Thursday of each month.

Hawaii

RADIOLOGICAL SOCIETY OF HAWAII. *Secretary*, H. C. Chang, M.D., 1282 Emma St., Honolulu 13. Meets third Monday of each month.

Illinois

CHICAGO ROENTGEN SOCIETY. *Secretary*, R. Burns Lewis, M.D., 670 N. Michigan Ave., Chicago 11. Meets at the University Club, second Thursday of October, November, January, February, March, and April at 8:00 P.M.

ILLINOIS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Stephen L. Casper, M.D., Physicians and Surgeons Clinic, Quincy.

ILLINOIS STATE MEDICAL SOCIETY, SECTION ON RADIOLOGY. *Secretary*, George E. Irwin, Jr., M.D., 427 N. Main St., Bloomington.

Indiana

INDIANA ROENTGEN SOCIETY. *Secretary-Treasurer*, John A. Robb, M.D., 238 Hume-Mansur Bldg., Indianapolis 4. Meets twice a year, first Sunday in May and during fall meeting of State Medical Association.

TRI-STATE RADIOLOGICAL SOCIETY (Southern Indiana, Northwestern Kentucky, Southeastern Illinois). Secretary-Treasurer, Stephen N. Tager, M.D., 219 Walnut St., Evansville 9, Ind. Meets last Wednesday, October, January, March, and May, 8:00 P.M., at the Elks' Club, Evansville, Ind.

Iowa

IOWA RADIOLOGICAL SOCIETY. *Secretary*, James T. McMillan, M.D., 1104 Bankers Trust Bldg., Des Moines. Meets during annual session of State Medical Society, and in the Fall.

Kansas

KANSAS RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, A. M. Cherner, M.D., Hays, Kansas. Meets in the Spring with the State Medical Society and in the Winter on call.

Kentucky

KENTUCKY RADIOLOGICAL SOCIETY. *Secretary*, David Shapiro, M.D., Veterans Administration Hospital, Louisville 6. Meets monthly, second Friday, at Seelbach Hotel, Louisville.

Louisiana

ORLEANS PARISH RADIOLOGICAL SOCIETY. *Secretary*, Joseph V. Schlos er, M.D., Charity Hospital of Louisiana, New Orleans 13. Meets second Tuesday of each month.

RADIOLOGICAL SOCIETY OF LOUISIANA. *Secretary-Treasurer*, J. T. Brierre, M.D., 700 Audubon Bldg., New Orleans.

SHREVEPORT RADIOLOGICAL CLUB. *Secretary*, W. R. Harwell, M.D., 608 Travis St. Meets monthly September to May, third Wednesday.

Maine

MAINE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Walter A. Russell, M.D., Augusta General Hospital, Augusta. Meets in June, October, December, and April.

Maryland

BALTIMORE CITY MEDICAL SOCIETY, RADIOLOGICAL SECTION. *Secretary-Treasurer*, Paul W. Roman, M.D., 1810 Eutaw Place, Baltimore 17. Meets third Tuesday, September to May.

MARYLAND RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Paul W. Roman, M.D., 1810 Eutaw Place, Baltimore 17.

Michigan

DETROIT X-RAY AND RADIUM SOCIETY. *Secretary*, E. F. Lang, M.D., Harper Hospital, Detroit 1. Meets first Thursday, October to May, at Wayne County Medical Society club rooms.

Minnesota

MINNESOTA RADIOLOGICAL SOCIETY. *Secretary*, John R. Hodgson, M.D., The Mayo Clinic, Rochester. Meets in Spring and Fall and at annual meeting of State Medical Association.

Mississippi

MISSISSIPPI RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, John W. Evans, M.D., 117 N. President St., Jackson, Miss. Meets monthly, on third Tuesday, at 6:30 P.M., at the Rotisserie Restaurant, Jackson.

Missouri

RADIOLOGICAL SOCIETY OF GREATER KANSAS CITY. *Secretary*, James E. McConchie, M.D., First National Bank Bldg., Independence, Mo. Meets last Friday of each month.

ST. LOUIS SOCIETY OF RADIOLOGISTS. *Secretary*, Wm. B. Seaman, M.D., 510 South Kingshighway, St. Louis 10. Meets on fourth Wednesday, October to May.

Montana

MONTANA RADIOLOGICAL SOCIETY. *Secretary*, Grant P. Raitt, M.D., 413 Medical Arts Bldg., Billings. Meets annually.

Nebraska

NEBRASKA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, James F. Kelly, Jr., M.D., 816 Medical Arts Bldg., Omaha. Meets third Wednesday of each month at 6 P.M. in Omaha or Lincoln.

New England

CONNECTICUT VALLEY RADIOLOGICAL SOCIETY. *Secretary*, B. Bruce Alicandri, M.D., 20 Maple St., Springfield, Mass. Meets second Friday of October and April.

NEW ENGLAND ROENTGEN RAY SOCIETY. *Secretary*, Stanley M. Wyman, M.D., Massachusetts General Hospital, Boston 14. Meets monthly on third Friday, October through May, at the Hotel Commander, Cambridge, Mass.

New Hampshire

NEW HAMPSHIRE ROENTGEN SOCIETY. *Secretary*, Albert C. Johnston, M.D., 127 Washington St., Keene.

New Jersey

RADIOLOGICAL SOCIETY OF NEW JERSEY. *Secretary*, Carye-Belle Henle, M.D., 195 N. 7th St., Newark. Meets at Atlantic City at time of State Medical Society and midwinter in Elizabeth.

New York

BUFFALO RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Clayton G. Weig, M.D., 135 Linwood Ave., Buffalo. Meets second Monday, October to May.

CENTRAL NEW YORK ROENTGEN SOCIETY. *Secretary*, Dwight V. Needham, M.D., 608 E. Genesee St., Syracuse 2. Meets in January, May, and October.

KINGS COUNTY RADIOLOGICAL SOCIETY. *Secretary*, Solomon Maranov, M.D., 1450 51st St., Brooklyn 19. Meets fourth Thursday, October to April (except December), at 9:00 P.M., Kings County Medical Bldg.

NASSAU RADIOLOGICAL SOCIETY. *Secretary*, Alan E. Baum, M.D., Hicksville, N. Y. Meets second Tuesday, February, April, June, October, and December.

NEW YORK ROENTGEN SOCIETY. *Secretary*, Sidney Rubenfeld, M.D., 477 First Ave., New York 16.

NORTHEASTERN NEW YORK RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Donald H. Baxter, M.D., Albany Hospital, Albany. Meets in the capital area second Wednesday, October, November, March, and April. Annual meeting in May or June.

RADIOLOGICAL SOCIETY OF NEW YORK STATE. *Secretary-Treasurer*, Mario C. Gian, M.D., 610 Niagara St., Buffalo. Meets annually with the State Medical Society.

ROCHESTER ROENTGEN-RAY SOCIETY. *Secretary-Treasurer*, Henry H. Forsyth, Jr., M.D., 40 Meigs St., Rochester 7. Meets at Strong Memorial Hospital, 8:15 P.M., last Monday of each month, September through May.

WESTCHESTER RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Maynard G. Priestman, M.D., New Rochelle Hospital, New Rochelle, N. Y. Meets third Tuesday of January and October and at other times as announced.

North Carolina

RADIOLOGICAL SOCIETY OF NORTH CAROLINA. *Secretary*, Waldemar C. A. Sternbergh, M.D., 1400 Scott Ave., Charlotte 2. Meets in April and October.

North Dakota

NORTH DAKOTA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, H. Milton Berg, M.D., Quain & Ramstad Clinic, Bismarck. Meets in the Spring with State Medical Association; in Fall or Winter on call.

Ohio

OHIO STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, M. M. Thompson, Jr., M.D., 316 Michigan St., Toledo.

CENTRAL OHIO RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Arthur R. Cohen, M.D., 41 S. Grant Ave., Columbus. Meets second Thursday, October, November, February, April, and June, 6:30 P.M., Fort Hayes, Hotel Columbus.

CLEVELAND RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, H. F. Inderlied, M.D., 11311 Shaker Blvd., Cleveland 4. Meets at 6:45 P.M. on fourth Monday, October to April, inclusive.

GREATER CINCINNATI RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Wm. R. Dickens, M.D., Cincinnati General Hospital, Cincinnati 29. Meets first Monday of each month, September to June, at Cincinnati General Hospital.

MIAMI VALLEY RADIOLOGICAL SOCIETY. *Secretary*, W. S. Koller, M.D., 60 Wyoming St., Dayton. Meets monthly, second Friday.

Oklahoma

OKLAHOMA STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, John R. Danstrom, M.D., Medical Arts Bldg., Oklahoma City.

Oregon

OREGON RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Fred C. Shipps, M.D., 214 Medical-Dental Bldg., Portland 5. Meets monthly, second Wednesday, October to June, at 8:00 P.M., University Club, Portland.

Pacific Northwest

PACIFIC NORTHWEST RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, J. Richard Raines, M.D., 214 Medical-Dental Bldg., Portland 5, Ore. Meets annually in May.

Pennsylvania

PENNSYLVANIA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, James M. Converse, M.D., 416 Pine St., Williamsport 8. Meets annually.

PHILADELPHIA ROENTGEN RAY SOCIETY. *Secretary*, Herbert M. Stauffer, M.D., Temple University Hospital, Philadelphia 40. Meets first Thursday of each month at 5:00 P.M., from October to May, in Thompson Hall, College of Physicians.

PITTSBURGH ROENTGEN SOCIETY. *Secretary-Treasurer*, Donald H. Rice, M.D., 4800 Friendship Ave., Pittsburgh 24. Meets monthly, second Wednesday, at 6:30 P.M., October to May, at the Hotel Roosevelt.

Rocky Mountain States

ROCKY MOUNTAIN RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, John H. Freed, M.D., 4200 East Ninth Ave., Denver 7, Colo.

South Carolina

SOUTH CAROLINA RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, William A. Klauber, M.D., Self Memorial Hospital, Greenwood. Meets with State Medical Association in May.

South Dakota

RADIOLOGICAL SOCIETY OF SOUTH DAKOTA. *Secretary-Treasurer*, Donald J. Peik, M.D., 303 S. Minnesota Ave., Sioux Falls. Meets during annual meeting of State Medical Society.

Tennessee

MEMPHIS ROENTGEN CLUB. *Secretary*, Harvey Thompson, M.D., 899 Madison Ave. Meets first Monday of each month at John Gaston Hospital.

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UTAH STATE RADIOLOGICAL SOCIETY. *Secretary-Treasurer*, Angus K. Wilson, M.D., 343 S. Main St., Salt Lake City 1. Meets third Wednesday, January, March, May, September, November.

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ABSTRACTS OF CURRENT LITERATURE

ROENTGEN DIAGNOSIS

The Head and Neck

MALAMUD, N., AND GAROUTTE, BILL. Pneumoencephalography in Children with Mental Defect and/or Cerebral Palsy 755

PERESE, DOGAN M., ET AL. Complications Following Cerebral Angiography 755

SIROIS, JEAN, ET AL. Unusual Local Complication of Percutaneous Cerebral Angiography .. 755

BÉTOULIÈRES, P., ET AL. Encephalic Pneumostratigraphy a minima 756

SEAMAN, WILLIAM B., AND FURLOW, LEONARD T. Anomalies of the Bony Orbit 756

RÜEDI, L. Diseases of the Sinuses in Childhood .. 756

ROTHSTEIN, EMIL, AND GALL, EDWARD B. Cystic Hygroma of the Neck Arising After Thoracoplasty 757

HURWITZ, PAUL. Mandibulofacial Dysostosis ... 757

RÖSLI, A. A Contribution to the Symmetrical Radiography of the Zygomatic Arches 757

The Chest

WACHOWSKI, T. J. What Are We Getting out of the Routine X-Ray Chest Examination of Hospital Patients 757

COBB, SANFORD, ET AL. Determination of Total Lung Capacity in Disease from Routine Chest Roentgenograms 757

BLADES, BRIAN B. Surgical Management of Tumors of the Lung Discovered in X-Ray Surveys 758

JACKSON, HARRIS. Foreign Bodies in the Respiratory Tract 758

ADLER, DAVID, AND FULLER, DENIS. Foreign Bodies in the Trachea and Bronchi. A Review of 100 Cases in Children 758

LAURANCE, BERNARD. Haemoptysis, Bronchiectasis, and Foreign Body in Lung 758

BOYER, RICHARD C., AND RAMSAY, THOMAS R. Radiological Aspects of Emphysema of the Chest 758

OVERHOLT, RICHARD H., ET AL. Paradox of Bronchiectasis 759

KIRSHNER, J. J., ET AL. Diffuse Interstitial Fibrosing Pneumonitis 759

LINDEN, IRWIN H., AND STEFFEN, CHARLES G. Pulmonary Cryptococcosis 759

PEEPLES, WILLIAM J., AND SPENCE, MARTHA JANE. Pulmonary Cavitation Due to Histoplasma capsulatum 759

STOTT, HUGH. Histoplasmin Sensitivity and Pulmonary Calcification in Kenya 760

BROCARD, H., ET AL. Recurrent Ornithosis 760

JONES, MELVIN R., AND LYONS, HAROLD A. Spontaneous Pneumothorax 760

MIDDLEMASS, I. B. D. Deformity of the Oesophagus in Bronchogenic Carcinoma 760

KING, J. CASH, AND COLE, FRANCIS H. Pulmonary Cysts 760

MAHADEVAN, R. Giant Cysts of the Lung 761

FORSEE, JAMES H., AND BLAKE, HU A. Pulmonary Cystic Changes in Xanthomatosis 761

HOLCOMB, GEORGE W., JR., AND MATSON, DONALD D. Thoracic Neurenteric Cyst 761

MAHRER, PETER R., ET AL. Scleroderma: Relation of Pulmonary Changes to Esophageal Disease 762

DONIACH, I., ET AL. Lung Changes During Hexamethonium Therapy for Hypertension 762

ROSSETTI, MARIO. Concerning a Case of Carcinoma of the Pleura 762

PIDONE, GRAZIANO. Some Benign Mediastinal Tumors Studied with Pneumomediastinum .. 763

The Cardiovascular System

STEEN, R. E. Team Diagnosis of Congenital Heart Disease 763

GIRAUD, G., ET AL. Use of Mediastinal Pneumostratigraphy in the Study of Congenital Cardiopathies 763

McKINLAY, C. A. Comments on Detection of Cardiac Disease in Group Examinations 763

HILARIO, J., ET AL. Rapid Biplane Angiocardiography in the Tetralogy of Fallot 764

TEJADA VALENZUELA, CARLOS, ET AL. Structural Changes in Intrapulmonary Arteries Exposed to Systemic Pressures from Birth. Report of a Case of Tetralogy of Fallot with a Widely Patent Ductus Arteriosus and an Anomalous Right Pulmonary Artery Arising from the Celiac Axis 764

FERENCZ, CHARLOTTE, ET AL. Problem of Differential Diagnosis in Infants with Large Hearts and Increased Blood Flow to the Lungs 764

SLOAN, SOL, ET AL. Massive Dilatation of the Left Auricle: Report of Three Cases 764

GIBSON, STANLEY, ET AL. Congenital Pulmonary Stenosis with Intact Ventricular Septum 765

STEINER, ROBERT E., AND GOODWIN, JOHN F. Some Observations on Mitral Valve Disease . 765

MACPHERSON, I. The Clinical Approach to Mitral Disease 766

WHITAKER, WILLIAM, AND LODGE, THOMAS. The Radiological Manifestations of Pulmonary Hypertension in Patients with Mitral Stenosis 766

KEITH, JOHN D., ET AL. Complete Anomalous Pulmonary Venous Drainage 767

RONALD, JAMES. Pulmonary Arterio-Venous Fistula 767

RALPH, LESLIE L. Spontaneous Thrombosis of the Internal Carotid Artery 767

SAYER, WILLIAM J., ET AL. Mediastinal Tumor Simulated by Azygos Phlebectasia 768
TORI, GIULIO. The Radiological Demonstration of the Azygos and Other Thoraco-Abdominal Veins in the Living 768
DEWOLFE, VICTOR G., ET AL. Intermittent Claudication of the Hip and the Syndrome of Chronic Aorto-Iliac Thrombosis 768

The Breast

GROS, CH. M., AND SIGRIST, R. The Roentgen Differential Diagnosis Between Chronic Mastitis and Breast Carcinoma 769

The Digestive System

SINGLETON, EDWARD B. Lesions of the Esophagus in Infants and Children 769
CATALANO, D. Radiologic Aspects of the Inferior Esophagus: The Phrenic Ampulla and the Cardiac Antrum 770
LAME, EDWIN L., ET AL. Diagnosis of Malignant Lymphoma of Gastrointestinal Tract ... 770
TORGERSEN, JOHAN. Anatomy of the Pyloric Canal and the Etiology of Infantile Pyloric Stenosis 771
ROTH, HAROLD P., AND LIEBOWITZ, DANIEL. Pyloric Obstruction in Peptic Ulcer 771
MONCRIEF, WILLIAM H., JR. Perforated Peptic Ulcer in the Newborn: Report of a Case with Massive Bleeding 771
ABEL, W. The Roentgen Diagnosis of Erosive Gastritis 771
BERG, HANS HEINRICH. Cancer of the Stomach with Long Survival After Operation, and Its Early Diagnosis 772
ARNESON, WALLACE A., AND IHLE, CHARLES W., JR. Congenital Intrinsic Obstruction of the Duodenum, with Report of Three Cases 772
JAMPEL, SYDNEY, ET AL. Simultaneous Sigmoidoscopy and Barium Enema 772
DURHAM, MILTON W. Familial Cancer of the Colon 772
MACKENZIE, DONALD A., ET AL. Leiomyoma and Leiomyosarcoma of the Colon 773
ROLLANDI, ARISTIDE. Roentgen Manifestations of Lipoma of Colon 773
CHURCH, REYNOLD E., AND SCHWARTZ, A. DAVID. Polyps of the Rectum and Colon in Children. 773
WILSON, FRANCIS W. Primary Megacolon in Young Adults 773
BROCK, WILLIAM. Volvulus of the Cecum 774
SLOAN, ROBERT D., ET AL. Meckel's Diverticulum 774
SKLAROFF, DAVID M. Metastatic Carcinoma of Rectum to the Thyroid Gland: Correlation with Radioactive Iodine Studies 774
WIESER, C. A New Volumetric Method for Measuring Gallbladder Contraction After a Fatty Meal 774

The Musculoskeletal System

KLEINBERG, SAMUEL. Osteopetrosis 775
CRUICKSHANK, B., ET AL. Subarticular Pseudocysts in Rheumatoid Arthritis 775
NELIGAN, G. A., AND WARRICK, C. K. The Value of Radiology in the Diagnosis and Management of Pyogenic Osteitis in Childhood 776
NAYLOR, A., AND CHESTER-WILLIAMS, F. E. Myelomata of Bone. A Review of 25 Cases. 776
RUNGE, CARL F. Roentgenographic Examination of the Lumbosacral Spine in Routine Pre-Employment Examinations 776
FRANKEL, CHARLES J. Aspiration Biopsy of the Spine 776
COLONNA, PAUL C. Spondylolisthesis. Analysis of Two Hundred One Cases 777
WHITE, JAMES C., AND HANELIN, JOSEPH. Myelographic Sign of Branchial Plexus Avulsion ... 777
KUNKLE, H. MELVIN, AND CARPENTER, EARNEST B. A Simple Technique for X-ray Measurement of Limb-Length Discrepancies 777
GIANNESTRAS, NICHOLAS. Legg-Perthes Disease in Twins 777
SONNENSCHEIN, ARNOLD. Roentgenographic Visualization of the Patella 777
HOLT, JOHN F., ET AL. Physiological Bowing of the Legs in Young Children 778
WILSON, JAMES N. Profiles of the Carpal Canal. 778
BARTFELD, HARRY. Gout in a Negro Woman. Report of a Case 778
MILCH, ROBERT A. Osteochondroma of the Astragalus 778
WALTON, J. N., AND WARRICK, C. K. Osseous Changes in Myopathy 779

Gynecology and Obstetrics

KIKA, KANJI. A Clinical Analysis of the "Angiograms" Found in the Course of Hysterosalpingography with Special Reference to Tuberculosis of the Female Genitals 779
FINKLE, ALEX L., ET AL. On the Incidence of Calcified Uterine Fibroids 779
HALL, JAMES W. Migration of Foreign Body Following Criminal Abortion 779
CRICK, A. F., AND SIMS, F. H. Gas Within the Foetus Indicating Foetal Death 779
CARABELLO, NATAL C. A General Formula for Pelvicephalometry 779
LIEBERMAN, JULIUS, ET AL. Simplified Roentgen Cephalometry 780
SCHWARZ, GERHART S. A Simplified Method of Correcting Roentgenographic Measurements of the Maternal Pelvis and the Fetal Skull ... 780

The Genitourinary System

POTTS, IAN F. Translumbar Aortography 780
GODLOWSKI, Z. Z. The Value of the Perirenal Insufflation of Air as a Diagnostic Method of Estimating Gross Anatomical Enlargement of the Suprarenals and Kidneys 780

SEIDMAN, EDWIN A., ET AL. Presacral Pneumography ... 781
DE LAMBERT, BASIL M., AND GREENSLADE, NORMAN F. Cystourethrography in the Male ... 781
GIVNER, DAVID. Renal Displacement and Pyelographic Deformity Produced by Amebic Infection of the Liver ... 781
SLATER, GREGORY S., AND MANDELL, JOSEPH. Fate of Hydronephrotic Kidney (Aortographic and Retroperitoneal Pneumographic Findings) ... 781
MORTENSEN, JD, AND BAGGENSTOSS, ARCHIE H. Nephrocalcinosis: A Review ... 781

Hydatid Disease

LATHAM, W. J. Hytadid Disease. Part II. Hydatid Disease in the Renal Tract, Bone, Muscles, and Nervous System ... 782

Technic

HODGES, PAUL C. Fast Cameras for All-Purpose Photofluorography ... 782
MORGAN, RUSSELL H., AND STURM, RALPH E. An Automatic Regulator for Providing Constant Brightness of the Fluoroscopic Screen ... 782
BÜCHNER, H. Direct X-Ray Enlargement and Normal Views. Comparative Studies for Clinical Limitations (Part I) ... 782
WERNER, K., AND BADER, W. Roentgen Recognition of Small Bone Defects by Direct X-Ray Magnification and Tomographic Magnification with the Fine-Focus Tube ... 783

RADIOTHERAPY

OSBORNE, EARL D. Treatment of Malignant Cutaneous Lesions ... 783
LEHMANN, C. F., AND PIPKIN, J. L. Radium in Malignant Cutaneous Disease ... 783
TRAUB, EUGENE F. Diagnosis and Treatment of Carcinoma of the Eyelids ... 784
HOWELL, J. B., AND RIDDELL, J. MURRAY, JR. Cancer of Forehead and Scalp ... 784
ANDREWS, GEORGE C., ET AL. Roentgen Irradiation in the Treatment of Epithelioma ... 784
WALTER, J. On the Treatment of Cavernous Haemangioma with Special Reference to Spontaneous Regression ... 784
MARTIN, CHARLES L. Treatment of Cancer of the Tongue and Its Cervical Metastases with Irradiation ... 785
MATTICK, WALTER L., AND MANCINI, ANTHONY J. Intrinsic Cancer of the Larynx, 1942–1949 ... 785
WELTI, H., AND RUSCH, G. Malignant Tumors of the Thyroid Gland ... 785
COHEN, MORLEY, AND MOORE, GEORGE E. Malignant Lesions of the Thyroid ... 786
FURR, WALTER E., JR., AND CRILE, GEORGE, JR. Struma Lymphomatosa: Clinical Manifestations and Response to Therapy ... 786
ETTER, H. Rotation Therapy for Carcinoma of the Esophagus. Comparison of the Depth Dose with 200 kv and 31 mv ... 787
BUSCHKE, FRANZ. Surgical and Radiological Results in the Treatment of Esophageal Carcinoma ... 787
HAAS, LEWIS L., ET AL. Radiation Management of Otherwise Hopeless Thoracic Neoplasms ... 787
NUTTALL, JOHN R. Radiotherapy for Inoperable Glands from Squamous-Cell Carcinoma ... 788
MEYER, OVID O. Treatment of Hodgkin's Disease and the Lymphosarcomas ... 788
HUNTER, ROBERT M., ET AL. The Use of Radium in the Treatment of Benign Lesions of the Uterus: A Critical Twenty-Year Survey ... 789
SCHINZ, H. R. Two Years of Research and Experience with the 31-MeV Betatron at the Kanton Hospital in Zürich ... 789
FRITZ-NIGGLI, HEDI. Biological Experiments with the 31-MeV Betatron ... 790

RADIOISOTOPES

GOLDSMITH, RICHARD E., AND SAENGER, EUGENE L. Results of Therapy with Radioactive Iodine in Hyperthyroidism ... 790
CHAPMAN, EARLE M., ET AL. Ten Years' Experience with Radioactive Iodide ... 790
FRASER, RUSSELL, ET AL. Radioiodine Treatment of Thyrotoxicosis: A Single Dose Method Following a Drug Preparation ... 791
ABBATT, JOHN D. Experiences of Management and Treatment of Polycythaemia Vera Using P^{32} as a Therapeutic Weapon ... 791
FRIEDELL, H. L., ET AL. An Evaluation of the Clinical Use of a Strontium^{90} Beta-ray Applicator with a Review of the Underlying Principles ... 791
CALLENDER, SHEILA T., ET AL. Estimation of Intrinsic Factor of Castle by Use of Radioactive Vitamin B_{12} ... 792
CALHOUN, J. ALFRED, ET AL. Comparative Exchange of Calcium, Lead, and Radioactive Lead in Dogs ... 792
MORGAN, KARL Z. Maximum Permissible Concentration of Radioisotopes in Food, Water and Air and Maximum Permissible Equilibrium Amounts in the Body ... 793
WAINWRIGHT, WILLIAM W., ET AL. Simplified Autoradiography Exposure Calculation ... 793

RADIATION EFFECTS

BROWN, W. M. COURT, AND MAHLER, R. F. Integral Dose, Body Size, and the Site of Irradiation as Factors Determining the Severity of Radiation Sickness ... 793
WILLIAMS, E. K. The White Cell Count in Relation to Occupational Radiation Dosage ... 794
MOESCHLIN, S. Fatal Panmyelopathy Produced by Thorotrast (Thorium Dioxide) ... 794

PATERSON, EDITH. Factors Influencing Recovery After Whole-Body Radiation..... 794
SPITTLER, AUGUST W., ET AL. Whole Body Irradiation on the Healing of Fresh Fractures. 795
RUGH, ROBERTS. Effect of X-Irradiation on Tissue Hydration in the Mouse..... 795
MULLER, H. J. The Manner of Dependence of the "Permissible Dose" of Radiation on the Amount of Genetic Damage..... 795
GRAY, L. H. Conditions Which Affect the Biologic Damage Resulting from Exposure to Ionizing Radiation..... 795
BACQ, Z. M. The Amines and Particularly Cysteamine as Protectors Against Roentgen Rays..... 796
FORSSBERG, A. Some Remarks on Chemical Protection Against Ionizing Radiation..... 796
BACQ, Z. M. On Chemical Protection Against Ionizing Radiation..... 796
LATARJET, RAYMOND. Spontaneous and Induced Cell Restorations After Treatments with Ionizing and Non-Ionizing Radiations..... 796

THE HEAD AND NECK

Pneumoencephalography in Children with Mental Defect and/or Cerebral Palsy. A Clinicopathologic Study. N. Malamud and Bill Garoutte. Am. J. Dis. Child. **87**: 16–25, January 1954.

The brains of 30 children who died in institutions for the feebleminded were examined and the findings correlated with the findings on encephalograms obtained during the patients' lives. Twenty of the brains exhibited cerebral malformations and 10 showed destructive lesions resulting from birth trauma, postnatal infection, etc.

The 20 cerebral malformations comprised 17 cases of cerebral anomalies and 3 cases of agyria. Several of the brains were microcephalic. The anomalies included many non-specific disturbances in the patterns of convolutions and sulci, including examples of microgyria, pachygyria, and polygyria. The occipital and frontal lobes tended to be small, in contrast to bulky temporal and parietal lobes. In most cases, lateral skull films showed a tendency to flattening of the occipital region, which finding the authors consider significant in relation to the small size of many of the occipital lobes.

There were 10 cases of secondary amentia due to various acquired lesions. Several patho-anatomic patterns were encountered. Five cases had more or less generalized cortical atrophy, associated in some instances with leptomeningeal thickening. One brain showed severe cystic degeneration of the white matter, together with marked enlargement of the ventricles. In 2 patients there was cerebral hemiatrophy, in which the pneumoencephalograms clearly depicted unilateral cystic lesions and homolateral ventricular enlargement. Asymmetry of the skull was not encountered in these cases.

Cerebellar disorders were found in a total of 14 cases: 4 of them primary cerebellar atrophy, 9 secondary atrophy, and 1 congenital hypoplasia of the cerebellum. Pneumoencephalograms showed the cerebellum to be small in all 4 instances of primary atrophy, and lobulated in 1 of these. The fourth ventricle was large in 3 of the primary atrophies, normal in the fourth. The cisterna magna was large in 1 case of primary atrophy, and in the example of hypoplasia of the cerebellum.

The authors warn against the use of terms such as "cortical," "cerebral," or "cerebellar atrophy," in the interpretation of pneumoencephalograms, because very poor correlation is obtained between patterns of subarachnoid air on pneumoencephalograms and the form of convolutional patterns at autopsy. They urge adherence to more anatomic designations in reporting air-contrast examinations.

Seven pneumoencephalograms; 8 photographs.

ARTHUR S. TUCKER, M.D.
Cleveland Clinic

Complications Following Cerebral Angiography. Dogan M. Perese, William C. Kite, Arthur J. Bedell, and Eldridge Campbell. Arch. Neurol. & Psychiat. **71**: 105–113, January 1954.

Cerebral angiography, while widely accepted as an extremely valuable method in the detection of vascular lesions and in the identification and localization of brain neoplasms, is nevertheless attended by certain untoward and occasionally fatal complications. The authors encountered 37 complications in a review of 234 consecutive carotid angiographies performed upon 200 patients between 1947 and 1952 at the Albany Medical College, New York. All patients were studied with 35 per cent Diodrast; 8 to 10 c.c. of the medium was used for each injection, and the total amount varied from 10 to 60 c.c. in each carotid artery.

One fatality occurred, which was clearly due to use of an excessive amount of the medium (6 injections of 10 c.c. within forty minutes). The patient was a seven-year-old boy who at autopsy was found to have an arteriovenous aneurysm between the left middle meningeal artery and the veins of Labbé. In 6 other patients, already in terminal stages of their illnesses, death was apparently hastened.

Three permanent hemiplegias occurred, presumably the result of the procedure, and 19 transient hemiplegias or hemipareses. Contralateral sensory changes of a transient nature were observed in 6 patients. Two patients had neck hematomas which healed following evacuation. In 1 case there was occlusion of the branches of a retinal artery, recorded by serial retinal photographs.

Eight case abstracts are presented.

Seven retinal photographs; 2 tables.

JOHN F. RIESSER, M.D.
Springfield, Ohio

Unusual Local Complication of Percutaneous Cerebral Angiography. Jean Sirois, Henri Lapointe, and Paul E. Côté. J. Neurosurg. **11**: 112–116, January 1954.

The authors attempted percutaneous left carotid arteriography in a fifty-year-old patient who had symptoms of a left-sided, expanding, intracranial lesion, but no filling of the cerebral vessels occurred. A strong flow of blood was obtained prior to each of three injections of Diodrast. With a fourth injection, films of the carotid region were obtained which showed almost complete occlusion of the common carotid artery at a point midway between the tip of the injecting needle and the bifurcation of the artery. A diagnosis of thrombosis was suggested, but this was not in accord with the clinical history. Right percutaneous angiography showed displacement of the right anterior cerebral artery, indicative of an expanding lesion in the left temporal lobe, but the patient was not considered to be in condition for intracranial exploration. The following day he died.

Autopsy revealed a large spongioblastoma of the left temporal lobe. The left common carotid artery contained no thrombus, but there was a small valvula at the site of the needle punctures caused by cutting of the intima for about a third of its diameter, due apparently to lateral movement of the injection needle during manipulation. Evidently the blood flow dilated this valvula and caused pocketing of blood between adventitia and detached intima, thus producing a picture of obstruction which suggested thrombosis.

The authors advise the use of a needle with a short dull point for percutaneous angiography, in order to avoid damage to the vessel which might lead to an erroneous diagnosis.

Four roentgenograms; 3 photographs; 1 drawing.

ARTHUR S. TUCKER, M.D.
Cleveland Clinic

Encephalic Pneumostratigraphy a minima. P. Bétoulières, R. Paleirac, R. Labauge, and J. Bassède. J. de radiol. et d'électrol. **35:** 27–30, 1954. (In French)

A method is described by which accurate outlines of the basal cisterns, the cisterna magna, and the ventricular system are obtained with small amounts of air, 30 to 40 c.c. at most.

With the patient's head in extension, a small amount of air is introduced to outline the basal cisterns. Some of this air goes into the subarachnoid spaces over the cerebral hemisphere and may go into the pericallosal cisterns. With the head in extreme flexion, the air goes into the cisterna magna. In intermediate stages the air is allowed to flow into the ventricular system.

Stratigrams (planigrams, tomograms) are taken in lateral and postero-anterior projections to outline the ventricular system and the region of the insula.

Six roentgenograms; 2 drawings.

CHARLES M. NICE, M.D.
University of Minnesota

Anomalies of the Bony Orbit. William B. Seaman and Leonard T. Furlow. Am. J. Roentgenol. **71:** 51–59, January 1954.

Defects in bones forming the orbit may be congenital or acquired. Congenital defects are relatively rare, and their recognition is important so that the changes may not be misinterpreted as bone destruction due to a malignant process, an error which has several times been recorded.

The essential feature of these anomalies is absence or failure of development of that portion of membranous bone which separates the cranial contents from those of the orbit. If this defect is large enough, a portion of the cranial contents may prolapse into the orbit, displacing the eye and producing a pulsating exophthalmos. When this occurs the condition may properly be described as an orbital meningocele.

Two cases are presented in detail. Roentgen examination of the skull in an eleven-month-old infant revealed absence of the usual bony landmarks in the left orbit, such as the optic foramen, superior orbital fissure, and lesser wing of the sphenoid. An osseous hiatus was present in the temporal region usually occupied by the greater wing of the sphenoid. The second case showed complete absence of the orbital portion of the frontal bone. The greater wings of the sphenoid were wholly absent and the superior orbital fissures were not seen. In neither of these cases was any underlying disease found at operation. In 2 other cases, abstracted briefly, there were associated evidences of neurofibromatosis.

The exact relationship of these bony defects to neurofibromatosis is not clear. It is believed that they are probably a manifestation of multiple congenital anomalies which may be found in the latter disease.

Eight roentgenograms; 3 drawings; 2 photographs.

M. HARLAN JOHNSTON, M.D.
Jacksonville, Fla.

Diseases of the Sinuses in Childhood. L. Rüedi. Schweiz. med. Wchnschr. **83:** 1247–1253, Dec. 26, 1953. (In German)

The author reviews in great detail the clinical and radiological findings encountered in various forms of sinusitis in children and discusses their medical and/or surgical treatment. Most of the paper deals with the maxillary sinuses.

Necrotizing ethmoiditis complicating scarlet fever is rarely seen at the present time, but acute exacerbation of chronic sinusitis seems to be on the increase in the area of Zurich Lake, from which this report comes. This form is usually seen in boys who spend a hot day diving and swimming. Subsequently they complain of headaches, edema of the lids, and fever. The frontal and ethmoid sinuses are usually affected, but the sphenoid sinuses can also be involved.

In cases of situs inversus viscerum and congenital bronchiectasis, an associated chronic maxillary sinusitis may be seen. In familial pancreatic fibrosis, also, one finds chronic changes in the sinuses in addition to bronchiectasis.

During recent years, more attention has been directed to the occult type of sinusitis in children, though reference to it appeared long ago in the German literature. In 1938, in a series of 88 autopsies, Mensing (Arch. f. Ohren-, Nasen- u. Kehlkopfh. **146:** 440, 1939) found pathological changes in the sinuses in 61 per cent; 55 per cent were localized in the maxillary sinuses.

Haike, in 1910 (Arch. Laryng. **23:** 206, 1910), wrote an excellent paper dealing with the roentgen interpretation of the sinuses, in which he stated that the maxillary and ethmoid sinuses are already present at the age of two years, while fully developed frontal sinuses may first be seen at the age of three and a half.

Roentgen examination of sinuses, as reported by various writers, has disclosed opacifications in the maxillary sinuses in from 13 per cent to 65 per cent of the cases examined. It was felt by Van Gilse (Ztschr. f. Hals-, Nasen- u. Ohrenheilkh. **16:** 202, 1926) that the mucosa in a growing sinus is relatively thick, and that therefore a haziness is not always indicative of inflammatory changes. In order to corroborate the roentgen findings, an additional examination by means of antral washings should be instituted. In 42 cases diagnosed radiologically as showing opacification of the antra, the authors found pus or mucus in the washings in only 31.

Constitutional and allergic factors can be considered as contributing to childhood sinusitis, but in most cases it appears subsequent to coryza. The author describes at great length the bacteriologic findings, discusses the relationship of the disease to hypertrophied adenoid tissue, and considers the symptomatology and diagnosis. He refers to Weber (Schweiz. med. Wchnschr. **81:** 207, 1951. Abst. in Radiology **58:** 764, 1952), who stated that an opacification of the maxillary sinuses could be diagnosed fluoroscopically with the patient gazing at the ceiling and the head slightly bent backward.

When an opacity of the antrum is discovered, one should consider rhinitis atrophicans as a precursor of ozena in the differential diagnosis. From the clinical standpoint chronic monosinusitis of the antrum and pansinusitis should be distinguished. Monosinusitis represents a chronic infection which usually does not produce complications in adult life.

The author discusses therapy at length, mentioning irradiation for chronically resistant cases. Schenck and Seldowitz (Am. J. Roentgenol. **67:** 240, 1952) irradiated the sinuses and hili of the lungs in 168 resistant cases, of which 58 per cent were cured and 28 per cent improved.

Three roentgenograms; 2 photographs.

JULIAN O. SALIK, M.D.
Baltimore, Md.

Cystic Hygroma of the Neck Arising After Thoracoplasty. Emil Rothstein and Edward B. Gall. J. Thoracic Surg. **27:** 103–105, January 1954.

The authors report a case of cystic hygroma of the neck developing three months after thoracoplasty for tuberculosis in a thirty-nine-year-old man. It appeared as a swelling in the right supraclavicular region, increasing to approximately 8 cm. in diameter. The only symptom was a slight discomfort upon swallowing. The mass was opaque on x-ray examination. Esophagrams and bronchograms showed no significant findings. The diagnosis was made at operation.

Possible diagnoses considered preoperatively were herniation of the lung, which was ruled out by opacity of the lesion and failure to show a communication, and arteriovenous aneurysm, ruled out by the absence of a murmur or thrill and by the fact that it was not completely obliterated by pressure.

The authors raise the question of whether or not surgery in this case may in some way have altered the anatomy or physiology so as to give impetus to the development of a potential hygroma.

One roentgenogram; 1 photograph.

RENE FORTIER, M.D.
St. Paul, Minn.

Mandibulofacial Dysostosis. Paul Hurwitz. Arch. Ophth. **51:** 69–72, January 1954.

A case of mandibulofacial dysostosis of the complete type, in a five-year-old boy, is reported. The following features of the condition were present: antimongoloid palpebral fissures (*i.e.*, sloping laterally downward), with colobomata of the outer portions of the lower lids and absence of the lashes in the lateral parts of the lids; hypoplasia of the malar bones, rudimentary zygomatic arches, micrognathia, and receding chin; malformation of the external ear; microstomia, high-arched palate, speech defect, irregular disposition of the teeth, and malocclusion; blind fistulae between angles of the mouth and ears; atypical hair growth with tongue-like extensions; diminution of the frontonasal angle; fish-like face; mental retardation. Other roentgenographic features not mentioned previously in association with the syndrome, were widening of the sella, accentuation of digital impressions of the skull, dolichocephaly, and defective inferior orbital margins.

Mandibulofacial dysostosis must be differentiated from cleidocranial dysostosis, craniofacial dysostosis (Crouzon), and acrocephaly with syndactyly.

Two roentgenograms; 2 photographs.

A Contribution to the Symmetrical Radiography of the Zygomatic Arches. A. Rösli. Radiol. clin. **23:** 12–35, January 1954. (In German)

For simultaneous demonstration of the zygomatic arches, the author avails himself of a very short target-film distance, thereby projecting the malar bones and the arches away from the sides of the skull. The patient lies comfortably on his back with his head slightly extended and the film supported against the vertex of the skull. The tube window is brought right to the chin in the midplane, and the central ray is projected submentobregmatically. The upper incisor teeth are positioned so that they fall on a line connecting the focus of the tube with the forehead.

Because of the short target-film distance and the slight thickness of the arch, only a brief exposure is necessary. Since the zygomatic regions are visualized not by the central ray but by the diverging peripheral rays, the zygomatic arch away from the anode will appear slightly magnified; the arch lying nearer the anode is sharper. It is therefore of advantage to put the side of particular interest nearer the anode.

The author describes the interesting preliminary research with a skull, pin-hole and electric light bulb that led him to the formulation of this technic.

Twenty-one figures, including 11 roentgenograms.

CHRISTIAN V. CIMMINO, M.D.
Fredericksburg, Va.

THE CHEST

What Are We Getting Out of the Routine X-Ray Chest Examination of Hospital Patients. T. J. Wachowski. Illinois M. J. **105:** 14–16, January 1954.

Of all patients admitted to the Copley Hospital, Aurora, Ill., between Feburary 1949 and October 1951, 25 per cent received routine chest x-ray examinations. Based on the observations in these 3,476 cases, similar studies of other investigators, and the results obtained by preventive medicine, the author makes a strong plea for routine use of this procedure.

Evidence of some type of pulmonary pathologic process was found in 54.1 per cent of the author's series, while some 10 per cent showed findings referable to the cardiovascular system. Nineteen patients (0.5 per cent) had clinically significant pulmonary tuberculosis, unsuspected by the clinician in 4 cases.

The help of radiologists in stressing the need for routine chest films, the aid of general practitioners in better follow-up control, and the assistance of hospitals in providing efficient low-cost examination are important for furthering this worth-while phase of preventive medicine.

E. E. TENNANT, M.D.
Denver, Colo.

Determination of Total Lung Capacity in Disease from Routine Chest Roentgenograms. Sanford Cobb, Donald J. Blodgett, Kenneth B. Olson, and Allan Stranahan. Am. J. Med. **16:** 39–54, January 1954.

In a group of 76 patients with pulmonary disease of various types, values for total lung capacity determined by volumetric measurement of routine posteroanterior and lateral chest roentgenograms were compared with values obtained by spirometry and an open circuit method of determining functional residual capacity. Comparisons and correlations were analyzed statistically. High degrees of correlation were obtained. The evidence suggested that accuracy of the radiologic determinations of total lung capacity was increased by subtracting the radiological volume of regions of disease on the roentgenogram and decreased by subtracting the radiological volume of the heart and mediastinum.

The closeness of correlation between radiological and gaseous methods of lung capacity determination in the group of subjects possessing volumetrically intact pulmonary tissue was sufficient to suggest soundness and feasibility of screening large numbers of individuals for abnormal changes in pulmonary compartment ratios by a combination of simple spirometry and radiological measurement of routine chest films.

Six roentgenograms; 1 chart; 5 tables.

HOWARD L. STEINBACH, M.D.
University of California, S. F.

Surgical Management of Tumors of the Lung Discovered in X-ray Surveys. Brian B. Blades. J.A.M.A. **154:** 196-198, Jan. 16, 1954.

Mass roentgenologic surveys have proved of tremendous value in the detection of pulmonary neoplasms. Guiss (Cancer **5:** 1035, 1952. Abst. in Radiology **61:** 284, 1953) found an incidence of 1.9 suspected tumors per 1,000 persons. Overholt and Woods (New England J. Med. **245:** 555, 1951. Abst. in Radiology **59:** 453, 1952) explored 67 persons in whom tumors had been suspected on x-ray examination and found that 39, or 60 per cent, had malignant lesions. All of the lesions were amenable to operation, and 70 per cent showed no evidence of lymphatic extension.

A coin shadow in the lungs usually represents either a tuberculoma or a neoplasm. The presence of calcium favors the former but is not conclusive unless a pattern of laminated calcific rings is present, since hemorrhage within a neoplasm may occasionally result in calcification. Attempts to categorize the type of tumor on roentgen examination, the author states, are neither reasonable nor desirable. Any persistent, unexplained lesion, whether large or small, deserves immediate and aggressive investigation. A wedge resection is used for biopsy. Frequently this is all that is necessary when the lesion proves to be a tuberculoma. In the case of a carcinoma, however, the consensus favors total pneumonectomy. With bronchial adenoma there is a sharp difference of opinion concerning the choice between lobectomy and pneumonectomy.

Some bronchogenic carcinomas are indolent for years, so that the establishment of the presence of a lung lesion for an extended period of time does not necessarily rule out lung carcinoma. An enlarged hilar shadow should be investigated bronchoscopically. It may be due to a tumor, tuberculous lymph nodes in the mediastinum, sarcoid disease, or an inflammatory process. Sometimes biopsy of the fat pad over the anterior scalenus muscle will reveal lymph nodes containing metastatic tissue, which will establish the true nature of the lesion. If a satisfactory solution to the diagnostic problem is not possible by these methods, the author recommends exploratory thoracotomy without hesitation.

Atelectasis is another sign which may give warning of the presence of a tumor, with or without symptoms. Localized emphysema may also be present. The atelectasis which occurs with tuberculosis may mask the development of a concomitant carcinoma.

Finally, the tendency of lung cancer to mimic viral pneumonia is mentioned as one of the most important single factors in delay of proper treatment. Patients with such a condition are usually symptomatic, however. For asymptomatic individuals the author recommends biannual full-sized roentgenograms of the chest, in both frontal and lateral projections, as the best method of early detection of lung neoplasms.

Four roentgenograms. ARTHUR S. TUCKER, M.D.
Cleveland Clinic

Foreign Bodies in the Respiratory Tract. Harris Jackson. South African M. J. **27:** 1150–1155, Dec. 19, 1953. **Foreign Bodies in the Trachea and Bronchi. A Review of 100 Cases in Children.** David Adler and Denis Fuller. Ibid., pp. 1155–1159.

Adler and Fuller review 100 cases of foreign body of the trachea and bronchi seen at the Transvaal Memorial Hospital for Children between 1943 and 1952, with emphasis on the clinical, therapeutic, and statistical aspects. Jackson presents 15 cases of foreign body in the respiratory tract, from the same hospital, with a brief comment on the radiologic investigation in each instance. He believes that there is a place for postero-anterior views in inspiration and in expiration, for lordotic and lateral views of the chest, and for antero-posterior and lateral views of the neck. Fluoroscopy and a barium swallow should also be employed. Both articles emphasize that a single negative roentgen study does not exclude the presence of a foreign body and in every case the decision whether or not to perform an endoscopic examination must be made with due consideration of the whole clinical picture. Jackson also emphasizes that a foreign body should be considered in every case of unexplained atelectasis or obstructive emphysema or whenever clinical examination suggests a laryngotracheal bronchitis.

Fifteen roentgenograms; 4 tables.

Haemoptysis, Bronchiectasis, and Foreign Body in Lung. Bernard Laurance. Brit. M. J. **1:** 125-127, Jan. 16, 1954.

The universal tendency of children to place objects in the mouth will often lead to the inhalation of a foreign body. A short, easily forgotten episode of choking can lead to a delay of months or years in investigation for their removal. Lung abscess and bronchiectasis will occasionally result. If a mother insists that her child has choked, gagged, or coughed with something in its mouth, a thorough roentgen search must be made. Minimum requirements are postero-anterior inspiration and expiration films and a lateral view.

Three case reports are presented. In the first, lung abscesses developed, followed by severe and recurrent hemoptyses. After a twelve-month illness a lobectomy revealed an ear of wild barley in the removed lung. The other two patients had persistent coughs. Foreign bodies were removed at bronchoscopy after films revealed evidence of obstructive emphysema in the second patient and atelectasis in the third. In the latter, follow-up study revealed bronchiectasis.

Lung abscess is rare in children even as a complication of aspirated foreign body. Chronic suppuration, in the right lung especially, is highly suggestive of a foreign body. Bronchography is usually essential after removal of such an object, as bronchiectasis is a frequent sequela. Hemoptysis is an uncommon complication of an inhaled foreign body.

One roentgenogram; 1 photograph.

JOHN F. RIESSER, M.D.
Springfield, Ohio

Radiological Aspects of Emphysema of the Chest. Richard C. Boyer and Thomas R. Ramsay. South. M. J. **47:** 10–16, January 1954.

The radiological aspects of certain types of emphysema of the chest are reviewed. It is pointed out that the word "emphysema" as it pertains to lungs, mediastinum, and the soft tissues of the thoracic wall, is merely descriptive and fails to indicate the clinical importance of the finding.

Soft-tissue emphysema of the chest wall occurs, usually, by one of two routes: (1) perforation of the chest wall, pleura, and lung (accompanied by pneumothorax); (2) alveolar rupture with dissection toward the lung root. In the latter case, mediastinal emphysema precedes the

development of the emphysema of the thoracic wall.

Mediastinal emphysema is potentially serious and is often accompanied by soft-tissue emphysema in the neck and chest wall and by pneumothorax. Radiologically mediastinal emphysema is identified by a vertical streaking of air in the mediastinum, best seen on the lateral view, and subpleural localization of air along the mediastinal parietal pleural reflections in the postero-anterior view.

Chronic pulmonary emphysema may be generalized or localized. Chronic senile or non-obstructive emphysema and compensatory emphysema are as a rule unimportant clinically. In the senile or postural variety, diaphragmatic movement is not restricted and the diaphragm is not flat, characteristics which serve to distinguish it from the true obstructive variety. In compensatory emphysema there may be increased radiolucency of the over-distended lung and shifting of the interlobar fissures and mediastinal structures.

True pulmonary emphysema is produced by localized or generalized obstructive phenomena within the tracheobronchial tree, with resultant thinning and rupture of the alveolar walls. Localized obstructive emphysema is one of the earliest signs of bronchial obstruction, and when small segments of the lung are involved, these are best studied and evaluated by the use of inspiration and expiration films. In addition to the localized radiolucent zone on the roentgenogram, decreased prominence of the vascular markings may be observed in the affected area.

Bullous emphysema is usually clinically unimportant and non-symptomatic in the older individual. It may, however, be progressive, resulting in compression atelectasis of the adjacent portions of the lung. The two most frequent complications are pneumothorax and secondary infection of the individual bullae. Radiologically bullous emphysema may be seen in the upper lobes as radiolucent zones separated by web-like septa.

Generalized obstructive emphysema is a slowly progressive disease involving both lungs. The obstruction occurs in the smaller bronchi and may be partial or nearly complete; it may be due to spasm, mucoid plugging, or post-inflammatory cicatricial changes. Radiologically this progressive disease manifests itself by flattening and relative immobility of the diaphragm and increased radiolucency of the lung fields. There is usually an increased postero-anterior diameter of the thorax with dorsal kyphosis. The ribs tend to become more horizontal and the interspaces widened, and as a result the sternum is elevated. On the lateral view there is an area of increased radiolucency retrosternally. The heart tends to assume a more vertical mid-line position, and in advanced cases signs of right heart enlargement are apparent.

Six roentgenograms. RICHARD E. OTTOMAN, M.D.
University of California, L. A.

Paradox of Bronchiectasis. Richard H. Overholt, Francis M. Woods, and Sherman W. Atwell. J.A.M.A. **154:** 193–196, Jan. 16, 1954.

The symptoms of septic bronchiectasis vary markedly. The lack of correlation between their severity and the extent of the disease is one of the paradoxes of the condition. The authors consider the disease to be one of the penalties imposed on modern man for his evolutionary assumption of an erect posture. Inability of the bronchial tree to expel secretions facilitates the formation of reservoirs that collect and concentrate the secretions, producing a medium favorable for culture of bacilli. When these concentrated secretions become viscid, they often defy expulsion until the multiplying organisms liquefy the medium.

The most important step in the recognition of bronchiectasis is bronchography. Mapping of the bronchial tree is best done in the side position with adequate tipping of the table and patient so that every bronchial orifice may be covered with a sufficient medium for gravitational filling. Even when the procedure is properly done, however, there are too many variables for it to be an indisputable method of diagnosis.

The only cure for the condition is excision. The authors prefer whenever possible to plan surgery on a segmental basis to preserve functioning tissue. Even a small focus of irreversible septic bronchiectasis is considered to constitute a far greater threat to life than excision. Because of difficulties in determining the existence and extent of the disease in some patients, decisions as to therapy must be made only after objective evaluation of all the evidence.

Three bronchograms; 4 photographs.
ARTHUR S. TUCKER, M.D.
Cleveland Clinic

Diffuse Interstitial Fibrosing Pneumonitis. J. J. Kirshner, R. L. Breckenridge, F. A. Allbritten, Jr., and P. A. Theodos. J.A.M.A. **154:** 336–338, Jan. 23, 1954.

A case of diffuse interstitial fibrosing pneumonitis is reported. The roentgenogram showed vascular congestion, pulmonary emphysema, and fibrosis. The diagnosis was made on biopsy and confirmed at autopsy.

One roentgenogram; 1 photomicrograph.

Pulmonary Cryptococcosis. Irwin H. Linden and Charles G. Steffen. Am. Rev. Tuberc. **69:** 116–120, January 1954.

The relatively high incidence of pulmonary involvement associated with central nervous system cryptococcosis has been well recognized. Pneumonitis alone due to *Cryptococcus neoformans* is quite rare, although some people feel that it may occur in unrecognized form more often than the number of reported cases would indicate. Pulmonary roentgenographic findings are varied and are not diagnostic; they include a fairly dense and massive shadow resembling a tumor (toruloma), small disseminated nodular shadows resembling tuberculosis, and a patchy pneumonitis with a predilection for the lung bases.

In the case reported here, the findings were those of a diffuse soft pneumonic type of infiltrate involving both lungs. The disease developed after discontinuation of a long-term course of cortisone therapy for pemphigus vulgaris and resolved spontaneously over a ten-week period.

Two roentgenograms. JOHN H. JUHL, M.D.
Minneapolis, Minn.

Pulmonary Cavitation Due to Histoplasma capsulatum. William J. Peeples and Martha Jane Spence. Am. Rev. Tuberc. **69:** 111–115, January 1954.

Pulmonary cavitation is relatively rare in histoplasmosis, having been reported in only 4 cases. In the case presented, massive cavities were present in both upper lung fields, and sputum smear and culture were positive for *Histoplasma capsulatum* on several oc-

casions. Although the patient was tuberculin-positive, repeated sputum studies failed to reveal the presence of tubercle bacilli. The histoplasmin skin test was positive, as was a complement-fixation test for *Histoplasma* in dilution 1:32. The patient was alive but with continuing extensive cavitation and pulmonary findings, three years after recovery of the organism and nearly four years after the onset of symptoms.

Since there are no characteristic roentgenographic findings in patients with cavitation due to pulmonary histoplasmosis, it is important to examine the sputum for fungi in cases with chest lesions resembling tuberculosis when search for tubercle bacilli is fruitless.

Two roentgenograms; 1 photomicrograph.

JOHN H. JUHL, M.D.
Minneapolis, Minn.

Histoplasmin Sensitivity and Pulmonary Calcification in Kenya. Hugh Stott. Brit. M. J. **1:** 22–25, Jan. 2, 1954.

Intradermal tests performed on 768 adult East African males showed a sensitivity rate of 8.5 per cent to 1:100 histoplasmin. A further 4.3 per cent showed a slight response to the test (indurations of less than 5 mm.). Roentgenograms were available for 130 of the histoplasmin-tested persons, and calcification was demonstrated in 12.3 per cent of these. It was present in about a third of the positive reactors, as compared to 13 per cent of tuberculin-positive subjects. Among tuberculin-positive subjects who showed also a positive histoplasmin sensitivity test, the incidence of roentgenologically demonstrable calcification was four times as great as among tuberculin reactors with negative histoplasmin tests.

This is said to be the first study of its kind in East Africa. It suggests that histoplasmosis is probably endemic in Kenya.

PAUL MASSIK, M.D.
Quincy, Mass.

Recurrent Ornithosis. H. Brocard, C. Choffel, and Ch. Gallouédec. J. franç. med. et chir. thor. **8:** 100–105, January 1954. (In French)

A 15-year-old male had three episodes of bronchopneumonia four months apart. The infiltration occurred in a different segment of the left lower lobe on each occasion. The complement-fixation test for ornithosis was positive. Each episode responded to Aureomycin.

It appears that here is another possible cause for the clinical picture of successive episodes of pneumonia occurring in different pulmonary segments.

Four roentgenograms.

CHARLES M. NICE, M.D.
University of Minnesota

Spontaneous Pneumothorax. Melvin R. Jones and Harold A. Lyons. Am. J. M. Sc. **227:** 13–20, January 1954.

Sixty cases of spontaneous pneumothorax were seen in four and a half years at the U. S. Naval Hospital, Philadelphia. This represents 3.7 per cent of the patients admitted to the chest service and 0.1 per cent of the total hospital admissions. Of the 60 patients, 59 were men between seventeen and seventy-one years of age. Two-thirds of the cases occurred in patients between the ages of twenty and twenty-nine years. Only one patient was found to have tuberculosis, and the authors believe that rupture of pleural blebs is the usual cause of spontaneous pneumothorax in healthy persons.

The diagnosis was confirmed roentgenologically in all cases. Full expiration aids in the demonstration of small pneumothoraces on both the fluoroscopic and roentgenographic examination.

Conservative management is favored. Forty-three of the 60 patients were treated with bed rest alone. Indications for catheter decompression of the pleural space by means of water-seal drainage with a Stedman pump include: failure of the collapse to decrease after five to seven days of bed rest; tension pneumothorax; physiologically impaired contralateral lung; associated cardiac disease with severe dyspnea.

Eight of the patients (13 per cent) presented recurrent pneumothorax. One was treated with 50 per cent glucose intrapleurally and one with talc *poudrage*. A third had multiple pleural blebs resected, but the remainder responded to conservative measures.

Six roentgenograms; 1 drawing; 4 tables.

R. F. LEWIS, M.D.
Cleveland Clinic

Deformity of the Oesophagus in Bronchogenic Carcinoma. I. B. D. Middlemass. J. Fac. Radiologists **5:** 121–125, October 1953.

An abnormal esophageal outline produced by mediastinal metastases was demonstrated in 35 of 112 cases of relatively early bronchogenic carcinoma. Positive findings were encountered most frequently in the postero-anterior and left anterior oblique views, rarely in the right anterior oblique. They consisted of localized extrinsic pressure defects without intrinsic mucosal abnormality, usually at or below the aortic arch. To demonstrate this finding, examination should be performed with the esophagus in a collapsed state and also distended with barium paste.

It is important not to confuse other appearances of the esophagus with those due to pressure from enlarged nodes. The only difficulty encountered by the author was the presence of an elongated and uncoiled aorta (1 case).

Positive findings of enlarged nodes always indicated an inoperable lesion. A normal esophageal outline in the presence of bronchogenic carcinoma does not exclude mediastinal metastases.

Fifteen roentgenograms.

MAURICE TATELMAN, M.D.
Detroit, Mich.

Pulmonary Cysts. J. Cash King and Francis H. Cole. Texas State J. Med. **49:** 864–873, December 1953.

The authors have classified pulmonary cysts as follows: (1) congenital or developmental cysts; (2) cystic cavities discovered in association with acute infections in the lungs of infants and young children; (3) cysts developing in certain volatile oil pneumonias; (4) emphysematous blebs or bullae.

Four cases of developmental cysts are reported. The first patient gave a history of recurrent episodes of respiratory symptoms and was admitted with clinical evidence of pneumonia. After chemotherapy, operation revealed a cyst communicating freely with the bronchial tree. The cyst acted as a reservoir of infectious material. In the second patient a suspicious shadow had been discovered in a routine radiographic

chest survey, but there was no communication with the remainder of the bronchial tree. In each of these 2 cases an anomalous systemic artery entered the lung in the region of the cyst. These arteries normally disappear early in fetal life. Those which persist below the root region have always been associated with cystic changes in the lung or congenital defects of the diaphragm. No anomalous arteries are described in association with the other 2 developmental cysts here reported.

Three cases are presented representing cystic processes developing upon or in the presence of pneumonic lesions. This type of cyst is peculiar to infants and children. The 3 cases were followed by serial radiographic examination, and in all the cysts appeared to clear almost completely without surgical intervention. However, rapidly expanding cysts producing tension and mediastinal shift, with death by asphyxia, are occasionally seen.

A single case is reported as due to aspiration of volatile oils. A child of eighteen months aspirated kerosene and, eight days after the first examination, showed roentgen evidence of bilateral pulmonary cysts. A loculated pneumothorax developed on the left, and the cyst in the right lung increased progressively in size. Eventually, bilateral tension pneumothorax occurred and aspiration and drainage of both pleural spaces was necessary. The patient gradually improved, and follow-up roentgenograms showed evidence of chronic disease in both lower lung fields, though no definite cysts could be delineated.

Three cases are used to illustrate emphysematous blebs, which usually occur in an older age group associated with generalized emphysema, and which are considered as degenerative changes in contrast to those occurring during the age of lung development. The higher incidence of emphysematous changes in the lungs currently being observed has been attributed to increased longevity, exposure to irritants, and respiratory infections.

The authors report, also, a case of congenital lobar emphysema, closely simulating a pulmonary cyst but requiring very different treatment. This patient was admitted with respiratory infection and roentgen examinations showed increased radiolucency in the right lung field. Exploration with a needle did not reveal a true cystic cavity. At thoracotomy the right middle lobe was found occupying almost the entire right hemithorax and herniating through the anterior mediastinum. The middle lobe was removed, and the remaining upper and lower lobes were expanded.

In their discussion, the authors stress the importance of frequent and judicious roentgen examinations in appraising the efficacy of therapeutic measures in pulmonary conditions, particularly in children. They further point out that conservative treatment of a cyst that compresses adjacent normal lung tissue should not be continued long enough to permit irreparable damage which in the end will result in sacrifice of a greater amount of lung tissue or in permanent crippling of the patient. Differentiation between congenital lobar emphysema and expansile air cysts is important because the best treatment of congenital lobar emphysema is surgical removal of the lobe as soon as the diagnosis is made.

Twenty-eight roentgenograms.

C. R. PERRYMAN, M.D.
Pittsburgh, Penna.

Giant Cysts of the Lung. R. Mahadevan. J. Indian M. A. **23**: 137–142, January 1954.

Five cases of giant or large solitary cyst of the lung are reported. In the one female patient in the series, the cyst caused recurrent attacks of spontaneous pneumothorax which ultimately became chronic and persistent. A roentgenogram revealed the true condition only after re-expansion of the lung.

Roentgenologically a giant cyst may sometimes superficially resemble a spontaneous pneumothorax, but it is always possible to distinguish one from the other on careful scrutiny. In a giant cyst, the lung structure will be found almost entirely around the thin pencil outline of the cyst wall; in spontaneous pneumothorax, the lung will be collapsed toward the hilus. In the case mentioned above, infection developed. Such a complication in non-tuberculous pneumothorax is considered unusual. The other 4 patients were admitted to the hospital with a diagnosis of lung abscess.

All 5 cases were treated surgically—1 by excision of the cyst, 1 by lobectomy, and 3 by segmental resection. The patients were doing well at the time of the report.

Sixteen roentgenograms; 5 photomicrographs; 3 photographs.

Pulmonary Cystic Changes in Xanthomatosis. James H. Forsee and Hu A. Blake. Ann. Surg. **139**: 76–83, January 1954.

The authors report 4 cases in which pulmonary cystic changes were associated with the normo-cholesteremic type of xanthomatosis. These cystic changes are believed to be due to two factors: (1) a granulomatous process involving the pulmonary interstitial tissues and (2) bronchiolar obstruction. Papillary outgrowths into the lumina of the bronchioles have been described. In one of the cases reported in this group a xanthomatous tumefaction was visualized, partially obstructing the left lower lobe bronchus.

The pulmonary roentgenographic findings in these cases and in others gathered from the literature consist primarily of multiple small cystic lesions in both lungs. The changes have been sometimes described as presenting a reticulated or trabeculated pattern.

The authors believe, from observation of these patients, that Hand-Schüller-Christian disease, Letterer-Siwe disease, lipoid granulomatosis, and eosinophilic granuloma of bone and lung may be outward manifestations of primary normo-cholesteremic xanthomatosis.

Eight illustrations, including 4 roentgenograms.

DEAN W. GEHEBER, M.D.
Baton Rouge, La.

Thoracic Neurenteric Cyst. George W. Holcomb, Jr., and Donald D. Matson. Surgery **35**: 115–121, January 1954.

A case of thoracic neurenteric cyst in a boy of four and a half years is reported. The presenting symptoms were severe cough and wheezing respiration of nine months duration. Roentgen examination demonstrated numerous congenital anomalies of the spine from C5 to D5, in the form of unmatched hemivertebrae, spina bifida, and vertebral body fusion. In addition, there was an anterior circular defect in the region of the 3d dorsal vertebra. From this region a soft-tissue mass projected toward the right. On myelography, the contrast medium was deflected about the mass, but none entered it.

A diagnosis of meningocele was made, but operation and microscopic study showed a neurenteric cyst, representing a persistent portion of the embryonic accessory neurenteric canal. The cyst was connected with the spinal cord by a fibrous stalk, 5 to 6 mm. in diameter, which passed through the circular defect in the 3d dorsal vertebral body.

Five roentgenograms; 1 drawing.

RICHARD E. OTTOMAN, M.D.
University of California, L. A.

Scleroderma: Relation of Pulmonary Changes to Esophageal Disease. Peter R. Mahrer, John A. Evans, and Israel Steinberg. Ann. Int. Med. **40:** 92–110, January 1954.

Esophageal lesions of scleroderma consist of muscle atrophy and replacement by fibrous tissue or fibrinoid sclerosis of the submucosa, with occasional loss of the mucosa. Roentgen changes consist of narrowing of the cardiac end of the esophagus, delay in passage of barium through this segment, and dilatation of the proximal esophagus. The normal mucosal pattern is lost.

The severity of pulmonary involvement in scleroderma varies. The roentgen picture is one of mottling of the lung parenchyma indistinguishable from pulmonary fibrosis, usually bilateral, involving the bases. The apparent fibrosis may be complicated by pulmonary hypertension or cor pulmonale.

Only cases with pulmonary changes were selected for this study. It is based on 41 cases from the literature and an additional series of 16. Esophageal lesions demonstrable roentgenologically or at autopsy and severe dysphagia occurred in 23 of the cases from the literature and in 11 of the authors' patients.

The present survey was undertaken to examine the possibility that the pulmonary changes in scleroderma are secondary to aspiration, since there is a well established association of aspiration pneumonitis and fibrosis with the dysphagia of cardiospasm. If aspiration were the chief cause of the pulmonary changes in scleroderma, esophageal lesions would be present in *all cases* with pulmonary findings. However, as stated, the incidence in the cases culled from the literature was only 56 per cent and in the authors' cases only 69 per cent. Apparently, therefore, aspiration is not the primary factor in this pulmonary disease.

Seven roentgenograms; 2 tables, summarizing the 57 cases.

JOHN F. RIESSER, M.D.
Springfield, Ohio

Lung Changes During Hexamethonium Therapy for Hypertension. I. Doniach, Brenda Morrison, and R. E. Steiner. Brit. Heart J. **16:** 101–108, January 1954.

In 3 of 54 patients with severe hypertension treated by hexamethonium, the authors observed lung infiltrations demonstrable radiologically after seven, nine, and twelve months of therapy, respectively. In the 2 cases which came to autopsy the pulmonary lesions were found to be similar to those observed in patients dying of heart failure associated with uremia. They are believed to represent organized fibrous pulmonary edema.

In Case I the infiltrates spread and then gradually cleared, even though the medication was continued. After clearing, some residual fibrosis could be seen. Case II showed extensive changes, and the hexamethonium was discontinued with the thought that it might be causing increased capillary permeability, but the patient's blood pressure rose rapidly and within a week he had a fatal cerebral hemorrhage. Case III was somewhat similar to Case I, in that the lung changes cleared under continuing medication, but the patient died of cardiac complications.

Postmortem findings of an organized fibrous edema in Cases II and III confirmed the radiologic diagnosis of pulmonary fibrosis. The edema is believed not to have been due to hexamethonium but to attacks of left heart failure which were modified by intermittent lowering of the blood pressure by the drug.

Seven roentgenograms; 6 photomicrographs; 3 graphs.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Concerning a Case of Carcinoma of the Pleura. Mario Rossetti. Radiol. clin. **23:** 35–41, January 1954. (In German)

Pleural tumors, other than metastatic, are considered rare. The benign varieties include fibroma, angioma, myxoma, chondroma, lipoma, and mixed forms. The malignant growths arise from the pleural endothelium and are referred to in the literature as endotheliomas or mesotheliomas. Their histogenesis and morphology are still not satisfactorily worked out. Even rarer are sarcomas arising from the subpleural tissues.

Primary pleural cancer may grow initially in circumscribed fashion, with later diffusion, or may take the form of a diffuse carcinosis from the beginning. The determination that the tumor is primary in the pleura is very difficult, even pathologically.

The author's patient was a 57-year-old man with progressive dyspnea for a year and a half, and a recurrent, non-hemorrhagic pleural effusion on the left side. His general condition was good, with no fever or weight loss, and only slight blood changes (80 per cent hemoglobin). Roentgenologically, there was a slight thickening of the left lower chest wall laterally, projecting into the pneumothoraces, which seemed to recur with undue facility after repeated taps. The thickening was initially believed to represent a fibrin mass, but this interpretation appeared unlikely when it was seen that its position was fixed when the patient was radiographed lying on his right side. Clinical and laboratory tests directed toward the diagnosis of tuberculosis and cancer were all negative. Surgery revealed a diffuse carcinomatosis involving both pleural layers, of completely unexpected extent. Sections of the tumor showed an "alveolar and papillary carcinoma in the pleura, poor in mitoses." The pathologist considered it possible that it was primary in the pleura.

This patient had relatively few of the findings that are reported in the literature as practically constant in carcinomas of the pleura: a chronically recurring effusion, hemorrhagic almost without exception, at least after repeated taps; severe dyspnea with cough; increased pleural thickening with diminution of the involved hemithorax; segmental chest pains; weight loss and an abnormal blood picture.

In retrospect, the unusually facile formation of pneumothoraces after the taps might have been regarded as a sign of loss of the normal tissue elasticity from neoplastic invasion. Spontaneous pneumothoraces have been described with metastatic involvement of the pleura. The value of examining the patient in different positions radiographically is emphasized by this case.

[The reader is referred to Willis' *Pathology of Tumors* (St. Louis, C. V. Mosby Co., 1948) for his concepts about the so-called primary tumors of the pleura. C. V. C.]

Two roentgenograms.

CHRISTIAN V. CIMMINO, M.D.
Fredericksburg, Va.

Some Benign Mediastinal Tumors Studied with Pneumomediastinum. Graziano Pidone. Radiol. med. (Milan) **40**: 24–36, January 1954. (In Italian)

The author describes his experiences with 5 benign mediastinal lesions studied with pneumomediastinum and laminagraphy. Unfortunately, he does not give details of his technic, describing it only as "transtracheal with injections of air never exceeding 300 c.c." Whereas the injection of air may be difficult in cases of primary or secondary malignant disease of the mediastinum because of the reduced capacity, it presents no difficulty in the presence of benign lesions such as cysts, struma, and aneurysms, because the mediastinal capacity is normal or almost normal. The air seems to have no difficulty in reaching these formations, bringing their margins into relief by freeing them completely from their bed.

The author's first patient was a sixty-year-old man with a shadow in the anterior superior mediastinum. While the patient did not consent to operation, the mass was so clearly delineated by air that it was almost certainly a cyst.

The second patient was a twenty-six-year-old man with hemoptysis. The standard examination showed a left superior mediastinal shadow, with inferior and medial borders so well demonstrated with air that a diagnosis of pulmonary cyst was made. This was confirmed by transparietal puncture and subsequent operation. The lateral tomograms disclosed a close connection between the mass and the main bronchus and pulmonary artery on the left.

The third patient, a man of fifty, with metastatic lymph nodes in the neck, was found to have a retrosternal struma. While this was visualized on the standard lateral study, it was best seen on the laminagram after pneumomediastinum. In addition, a right apical parenchymal mass was clearly delineated by laminagraphy following the pneumomediastinum.

The fourth and fifth cases illustrate the value of this method in the differential diagnosis between aortic aneurysm and cyst. The aneurysmal dilatations of the aortic arch and some of its branches were clearly visualized.

Twenty-seven roentgenograms.

CHRISTIAN V. CIMMINO, M.D.
Fredericksburg, Va.

THE CARDIOVASCULAR SYSTEM

Team Diagnosis of Congenital Heart Disease. R. E. Steen. Irish J. M. Sc., pp. 1–16, January 1954.

The diagnosis of congenital heart disease is carried out in two stages: (1) the differentiation of congenital forms from acquired heart disease; (2) the diagnosis of the type of congenital heart disease.

Three points are of help in differentiating the congenital from the acquired type: (1) Organic heart disease occurring before the age of two and a half years is almost certainly congenital. (2) *Organic murmurs* in childhood which are not rheumatic are almost certainly congenital. (3) Cyanosis, clubbing, and polycythema, when present and marked, are in favor of congenital heart disease.

The diagnosis of the type of congenital heart disease involves clinical evaluation, radiological investigation including fluoroscopy, cardiac catheterization, and occasional angiocardiography and electrocardiography. The technic of cardiac catheterization and angiocardiography is reviewed. Cardiac catheterization is a relatively safe procedure, but the author's practice has been to carry it out only in cases where operation was being considered and where a decision could not be reached by the ordinary methods of diagnosis. He feels, however, that angiocardiography is not nearly so safe a procedure as catheterization, and it is performed only if it is considered absolutely essential. Unfortunately it is in just the type of case which carries the greatest risk that the procedure is most valuable.

The importance of teamwork between the various contributing specialists is emphasized.

Seventeen illustrations, including 15 roentgenograms.

THEODORE E. KEATS, M.D.
University of California, S. F.

Use of Mediastinal Pneumostratigraphy in the Study of Congenital Cardiopathies. G. Giraud, P. Bétoulières, H. Latour, P. Puech, M. Pélissier, and F. Levère. J. radiol. et d'électrol. **35**: 37–41, 1954. (In French)

The authors suggest the use of pneumostratigraphy as a supplement to other studies of congenital cardiac disease in order to outline more exactly the external limits of arterial segments and vascular cavities. A pneumomediastinum is first created by one of several methods. The authors prefer the presacral injection of air or gas, which follows the retroperitoneal spaces to the mediastinum. Stratigrams (planigrams, tomograms) are taken to show the cardiac silhouette and great vessels.

The method is found to be of particular use in determining the status of the great vessels. Coarctation of the aorta has been clearly delineated. The anomalous entry of veins into the right atrium has also been demonstrated rather well. No great success has been obtained in patent ductus arteriosus.

Eight roentgenograms. CHARLES M. NICE, M.D.
University of Minnesota

Comments on Detection of Cardiac Disease in Group Examinations. C. A. McKinlay. Dis. of Chest **25**: 32–39, January 1954.

The author evaluates cardiac abnormalities found in his experience in pre-employment examinations, college entrance examinations, and periodic re-examinations at the University of Minnesota. He emphasizes the importance of obtaining a history and of evaluating physical findings such as tachycardia, hypertension, arrhythmia, and murmur. Minor variations from the normal electrocardiogram should not be emphasized. Similar caution is urged in the evaluation of abnormalities of cardiac contour encountered on photofluorograms.

All physicians who encounter abnormalities in supposedly normal people are urged to provide individualized attention for these patients. Follow-up examinations should be made with a care to avoid undue fear of cardiac disease and iatrogenic disturbance.

ARTHUR S. TUCKER, M.D.
Cleveland Clinic

Rapid Biplane Angiocardiography in the Tetralogy of Fallot. J. Hilario, J. Lind, and C. Wegelius. Brit. Heart J. **16**: 109–119, January 1954.

Twenty-three patients with tetralogy of Fallot were studied with the authors' rapid biplane technic. The procedure has been previously described (Fredzell, Lind, Ohlson, and Wegelius: Am. J. Roentgenol. **63**: 548, 1950. See also J. Fac. Radiologists **1**: 87, 1949. Abst. in Radiology **55**: 464, 1950). For the purposes of this study two lateral oblique views were obtained simultaneously.

As expected, the authors found constant enlargement of the vena cava, right atrium, and right ventricle. Surprisingly, in 8 cases right-to-left interatrial shunts were observed, which may explain why some patients are not much improved by a shunting operation.

Close study was made of the pulmonary outflow tract, particularly as to the site and degree of stenosis. It was found that in most cases the stenosis was subvalvular and that the infundibulum was usually narrowed to some degree. The authors believe that in as many as 60 per cent of cases direct surgical attack on the stenosis would be feasible.

Sixteen roentgenograms; 1 table.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Structural Changes in Intrapulmonary Arteries Exposed to Systemic Pressures from Birth. Report of a Case of Tetralogy of Fallot with a Widely Patent Ductus Arteriosus and an Anomalous Right Pulmonary Artery Arising from the Celiac Axis. Carlos Tejada Valenzuela, Julio Toriello, and Wilbur A. Thomas. Arch. Path. **57**: 51–61, January 1954.

The authors report a case presenting the basic anomalies of the tetralogy of Fallot with atresia of the pulmonary valve plus a widely patent ductus arteriosus and an anomalous systemic artery arising from the celiac axis and supplying the lower lobe of the right lung.

The patient, a boy of two and a half months, was admitted to the hospital because of recurrent cyanosis and retarded growth. Conventional roentgenograms of the chest showed narrowing of the rib spaces on the right, congenital anomalies of the spine, and diminished vascularity of the left lung, which had herniated across the mid-line. The heart was enlarged and displaced to the right. There was evidence of pressure on the barium-filled esophagus posteriorly, consistent with an aberrant right subclavian artery. Seventy per cent Diodrast injected into the right external jugular vein promptly filled the right ventricle and aorta, and shortly thereafter the left ventricle, suggesting an interventricular septal defect with dextroposition of the aorta. The left pulmonary artery was demonstrated but it, as well as its branches, was small. The main pulmonary trunk and the right branch were not visualized. A large anomalous artery was seen arising from the aorta below the diaphragm and extending obliquely cephalad into the right lung. The findings were interpreted as consistent with tetralogy of Fallot and sequestration of a large portion of the right lung, as manifested by the large anomalous pulmonary artery.

At the age of six months an operation was performed, with transection of the left pulmonary artery and an end-to-end anastomosis to an anomalous right subclavian artery arising from the posterior aspect of the arch. A few minutes after the anastomosis was completed, the infant died.

Histologic examination of the lungs revealed striking changes throughout the arterial tree. These consisted for the most part of thickening of the muscular coats of the small pulmonary arteries and retention of the fetal and neonatal muscular coat of the pulmonary arterioles. Another striking change was the presence of multiple organized recanalized emboli in many of the pulmonary arterioles and small arteries of the left lung.

A comparative study was made of the intrapulmonary arteries in the portion of the lung supplied by the systemic artery and in the portion supplied by the regular pulmonary arteries through the ductus arteriosus. All showed thick muscular walls resembling those of vessels of corresponding size in other tissues supplied by the general circulation.

A number of control lungs were studied, including 12 from persons with normal circulatory systems in the same age group and 1 from a patient with a similar type of tetralogy of Fallot but with a closed ductus arteriosus. Their thin-walled arteries contrasted sharply with those in the case presented.

Six roentgenograms; 1 photograph; 1 drawing; 11 photomicrographs.

Problem of Differential Diagnosis in Infants with Large Hearts and Increased Blood Flow to the Lungs. Charlotte Ferencz, Arnold L. Johnson, and Alton Goldbloom. Pediatrics **13**: 30–40, January 1954.

The authors report their observations with respect to the differential diagnosis of cardiac lesions in infants with enlarged hearts associated with increased blood flow to the lungs, in whom cyanosis was not a prominent feature. There were 25 patients in their series and in 19 of these the diagnosis was confirmed at autopsy. Eight patients had a patent ductus arteriosus, either as an isolated lesion or in association with other defects; 10 had ventricular septal defects with or without overriding of the aorta; 5 had anomalous pulmonary vein drainage; 1 had an ostium atrioventriculare communis, and in 1 there was a functional single ventricle.

The clinical, electrocardiographic, and radiologic findings are analyzed. Eight patients were studied by aortography and the diagnosis of patent ductus was made in 4 and excluded in 4 by this method.

The authors point out the lack of differential criteria in the exact diagnosis of the cardiac malformations in infants with large hearts and evidence of increased blood flow to the lungs. Important features which appear to favor the diagnosis of patent ductus in the absence of the characteristic continuous murmur are full or collapsing pulses and a normal electrocardiogram or one showing evidence of combined ventricular hypertrophy. Of lesser importance are an apical diastolic rumble and enlargement of the left atrium. Electrocardiographic and fluoroscopic evidence of marked hypertrophy of the right atrium and right ventricle renders the presence of a patent ductus unlikely, and is consistent with a diagnosis of anomalous drainage of pulmonary veins.

Ten roentgenograms; 1 graph; 3 tables.

ROBERT H. LEAMING, M.D.
Memorial Center, New York

Massive Dilatation of the Left Auricle: Report of Three Cases. Sol Sloan, R. C. Pollock, Jack Kirshbaum, and Toby Freedman. Ann. Int. Med. **40**: 75–91, January 1954.

Massive dilatation of the left auricle in chronic rheu-

matic carditis and mitral valvulitis is probably more common than the less than 50 published cases would indicate. Three cases are reported here. In 2 of these there was massive left auricular enlargement; the third case showed massive dilatation of both right and left auricle, this apparently being the first such case recorded.

The roentgen signs of gigantic enlargement of the left auricle, as illustrated by these cases, are reviewed. The prominence of the right cardiac border and the fact that extension of the left auricle to the right is probable with enlargement are discussed, along with the responsible anatomical features. Elevation of the left main bronchus is always found. An exaggeration of the normal right deviation of the barium-filled esophagus is usually seen, but in the authors' first case there was deviation to the left. Fluoroscopy shows diminished pulsation of the right side of the heart and also identifies the upper curve on the right with the posterior superior curve of the heart.

Angiocardiography was performed in the first of the cases reported here, but was not diagnostic. The enlarged left auricle did not fill, and differentiation from an extracardiac mass could not be established. There was considerable delay in circulation, with the medium remaining in the main pulmonary artery through six films.

In the one case which came to autopsy there was almost complete fibrous replacement of the left auricular muscle, resulting in loss of elasticity, with thinning and weakness of the wall. Mitral insufficiency throws a great burden on the left auricular wall and this, combined with weakening of the wall, undoubtedly plays a major role in massive dilatation of the auricle.

The 3 case histories are presented in rather full detail.

Five roentgenograms; 2 photographs; 2 photomicrographs. JOHN F. RIESSER, M.D.
Springfield, Ohio

Congenital Pulmonary Stenosis with Intact Ventricular Septum. Stanley Gibson, Harvey White, Frank Johnson, and W. J. Potts. Am. J. Dis. Child. **87**: 26–39, January 1954.

The authors report observations on 45 infants and children believed to have pulmonary stenosis with intact ventricular septum, seen at the Children's Memorial Hospital (Chicago). In 10 pulmonary valvulotomy was not done; all of this group died and autopsies were obtained. Among the 35 patients subjected to valvulotomy, there was one death, occurring during surgery on a poor-risk patient fourteen months of age. The authors emphasize the fulminating nature of the severer cases, with death occurring more or less suddenly in early life unless the condition is surgically relieved. Other patients are entirely asymptomatic or only slightly handicapped.

Cyanosis was seen in all 10 of the patients who died, and in 28 of the 35 who underwent surgery. Electrocardiograms revealed right heart strain in 7 of the former group and 31 of the latter. X-ray studies were considered to be most significant. The heart was considered large in 9 of the patients who did not have surgery, and in 28 of those who underwent operation. The vascularity of the lung fields was diminished or normal in all instances. Fluoroscopy revealed enlargement of the pulmonary artery segment in the anteroposterior or right oblique view in most cases. Autopsies of the patients who died revealed very similar lesions, with conical fusion of the cusps of the pulmonary artery and very tiny apertures. In every instance there were also poststenotic dilatation of the artery, enlargement of the right auricle and ventricle, and tricuspid stenosis and thickening.

The condition must be differentiated from other congenital heart lesions. The tetralogy of Fallot is more common, and is differentiated sometimes only by angiocardiography or cardiac catheterization. In tricuspid atresia the electrocardiogram shows left heart strain. Transposition of the great vessels gives a narrow mediastinum in the anteroposterior x-ray film, but may require cardiac catheterization or angiocardiography for diagnosis. Ebstein's anomaly produces a picture much like that of pulmonary stenosis with intact ventricular septum, but the electrocardiogram shows right bundle-branch block without right heart strain.

The treatment is surgical. Pulmonary valvulotomy may produce dramatic improvement in a moribund child. Infants with congestive heart failure are considered to be surgical emergencies. Because of close resemblance of the condition to the tetralogy of Fallot, 3 patients were operated upon without the establishment of the diagnosis as pulmonary stenosis with closed ventricular septum. One died after a shunt was established; another died even though no shunt was made. In the third case a second operation was done several months later, at which time the anastomosis was occluded and a pulmonary valvulotomy done, following which the patient did very well. The authors warn against the use of any form of shunt in treating pulmonary stenosis with an intact ventricular septum.

Six roentgenograms. ARTHUR S. TUCKER, M.D.
Cleveland Clinic

Some Observations on Mitral Valve Disease. Robert E. Steiner and John F. Goodwin. J. Fac. Radiologists **5**: 167–177, January 1954.

The authors discuss the varying appearances of the left auricle, the radiological diagnosis of mitral incompetence, and the pulmonary vascular pattern in mitral valve disease. Their remarks are based on a clinical and radiological study of 91 patients in whom mitral heart disease was considered to be the dominant valve lesion. A number of these cases had been submitted to mitral valvotomy. Special investigations in selected cases consisted of cardiac catheterization, tomography, angiocardiography, and microscopic examination of pulmonary vessels in specimens of lungs obtained at operation; postmortem pulmonary arteriography was performed in a few cases. The clinical criteria for the diagnosis of mitral incompetence were: enlargement of the left ventricle in the absence of any other cause for this; a loud early or mid-systolic murmur at the apex conducted into the axilla; a soft apical first heart sound; and an absent or faint opening snap of the mitral valve.

The Left Auricle: The left auricle was found to vary greatly in size, from minimal enlargement in asymptomatic mitral stenosis to aneurysmal proportions in severe mitral incompetence, with or without stenosis. The degree of valvular stenosis was not directly proportional to the size of the auricle.

An exact roentgen diagnosis of the degree of mitral incompetence is not always possible in the presence of mitral stenosis. The authors believe that, at present, the most reliable radiographic sign is the size of the left

auricle, which in most instances is grossly enlarged. In their experience, an auricle which forms the greater part of the right cardiac contour on straight postero-anterior films and also shows a prominent left auricular appendix in addition to considerable esophageal displacement in the first oblique projection has almost invariably been associated with clinical signs of mitral incompetence. Associated left ventricular enlargement is only suggestive of mitral incompetence in the absence of any other cause, such as significant aortic valve disease or hypertension. In their angiocardiographic studies of the left auricle, the authors were unable to demonstrate any intra-auricular thrombi. They did not find, as has been claimed by some writers, that opacification of the left auricle occurs earlier and is more intense in mitral incompetence than in mitral stenosis.

Intracardiac Calcification: The incidence of valvular calcification in rheumatic heart disease is high. It varies in degree from a tiny fleck in one of the valve leaflets to complete calcification of the cusps or annulus fibrosus. Of the 91 patients in the present series, 2 had demonstrable evidence of auricular calcification, 19 had mitral valve calcification, and 4 had aortic valve calcification. A heavily calcified mitral valve can be troublesome at operation, but calcified valves have been operated on successfully and their radiological demonstration need not be a contraindication to surgery. A preoperative radiologic diagnosis of valvular calcification, however, tells the surgeon what to expect.

Appearances of the Lungs: In many patients with mitral valve disease the pulmonary vascular pattern, with the exception of varying degrees of enlargement of the main pulmonary arteries, is normal. In these patients the pulmonary arterial pressure, as measured by cardiac catheterization is normal or only slightly elevated at rest. In others the pulmonary arterial pressure is elevated, and in these the pulmonary vascular pattern is abnormal.

Two types of pulmonary hypertension have previously been recognized: (1) passive pulmonary hypertension, which is the result of increased left auricular and pulmonary venous pressures, and which is associated with only a slight elevation in the pulmonary arterial pressure; (2) active pulmonary hypertension, which is the result of an increase in the pulmonary arteriolar resistance and is associated with higher pressures. The authors investigated the pulmonary vascular pattern by venous angiocardiography and by selective pulmonary arteriography. In patients with active pulmonary hypertension there was found to be considerable enlargement of the pulmonary arterial trunk and the main branches, associated with a significant degree of right ventricular hypertrophy. There is a diminution of the smaller arterial branches, particularly at the bases of the lungs and in the peripheral lung field. The authors agree with others that there is no correlation between left auricular size and the degree of pulmonary hypertension.

Pulmonary hemosiderosis was diagnosed in 25 per cent of the cases in the present series. It was usually, but not always, associated with pulmonary hypertension. In 2 patients with hemosiderosis, extensive pulmonary ossification was demonstrated; this is admittedly a rare complication.

Seventeen roentgenograms; 2 photomicrographs.

W. H. SOMERS, M.D.
Indiana University

The Clinical Approach to Mitral Disease. I. Macpherson. J. Fac. Radiologists **5**: 155–166, January 1954.

This is one of a group of articles dealing with the diagnostic aspects of mitral valvular heart disease. It consists of a well illustrated discussion in outline form of the salient clinical features of mitral disorders. The symptoms, auscultatory, electrocardiographic, and radiologic findings are summarized for each category of the following classification of mitral disease:

1. Mitral valvulitis (acute). Acute rheumatic carditis
2. Mitral valvulitis (chronic or healed). Minimal mitral valve disease
3. Pure mitral regurgitation
4. Mitral stenosis
   - (*a*) Early and mild
   - (*b*) Fully developed stenosis
   - (*c*) Tight mitral stenosis
     - (1) Simple uncomplicated (passive pulmonary hypertension)
     - (2) With pulmonary hypertension (acute pulmonary hypertension)
5. Mitral stenosis and regurgitation
6. Complicated mitral disease
   - (*a*) Active rheumatic carditis
   - (*b*) Auricular fibrillation
   - (*c*) Auricular thrombus
   - (*d*) Heart failure
   - (*e*) Other valve lesions
   - (*f*) Bacterial endocarditis

Nineteen figures, including 22 roentgenograms.

J. A. CAMPBELL, M.D.
Indiana University

The Radiological Manifestations of Pulmonary Hypertension in Patients with Mitral Stenosis. William Whitaker and Thomas Lodge. J. Fac. Radiologists **5**: 182–188, January 1954.

Twenty-five cases in which mitral stenosis was the sole or dominant lesion were analyzed by the authors, in an attempt to make an objective assessment of the relation between the radiological abnormalities and pulmonary hypertension. One author recorded the pulmonary artery blood pressures by cardiac catheterization, and the other reported the radiologic abnormalities without knowledge of the pressure records.

The pulmonary artery blood pressures were recorded with the tip of the catheter in the main pulmonary artery, and the pulmonary capillary pressures with the tip of the catheter wedged in a small branch of a pulmonary artery. The roentgenograms were all taken in the postero-anterior position, and the following features were assessed: (1) heart size; (2) pulmonary conus; (3) main pulmonary artery as seen on the left border of the cardiovascular shadow just below the arch of the aorta and above the conus; (4) the right and left main branches of the pulmonary artery as seen in the respective hili; (5) the perihilar vessels; (6) the peripheral vessels; (7) horizontal lines chiefly seen in the outer parts of both lower lobes, thought possibly to be due to congested subpleural lymphatics.

The pulmonary artery blood pressure in patients with mitral stenosis varies from normal to levels higher than the pressures in the systemic arteries. The resting pulmonary artery mean blood pressures were known in all 25 patients with mitral stenosis, and capillary pressures in 15 of the patients.

No relation was apparent between the degree of cardiac enlargement as demonstrated radiologically and the degree of pulmonary hypertension, though a heart of normal size suggests that the hypertension is of no more than mild degree.

Pulmonary conus enlargement was not found to be a reliable sign of pulmonary hypertension or an index of its degree. It was further observed that a large main pulmonary artery is a sign of pulmonary hypertension, but no index of its degree, and that there is a rough correlation between enlargement of the main branches of the pulmonary artery and the degree of pulmonary hypertension. Enlargement and increase in number of perihilar vessels is considered only a sign of pulmonary hypertension and not an index of its degree. Increased peripheral vasculature is indicative of moderate or severe pulmonary hypertension. "Horizontal lines" in the lung fields appeared to be a sign of moderate to severe pulmonary hypertension.

Six roentgenograms; 1 table.

W. H. SOMERS, M.D.
Indiana University

Complete Anomalous Pulmonary Venous Drainage. John D. Keith, Richard D. Rowe, Peter Vlad, and John H. O'Hanley. Am. J. Med. **16**: 23–38, January 1954.

The literature concerning total, uncomplicated, anomalous pulmonary venous drainage is reviewed. Fourteen cases in children, 13 proved by autopsy, are added to those previously reported. The main clinical findings in infants and children are lack of cyanosis and failure to thrive. Murmurs may be absent or faint initially, but later a peristernal systolic murmur between the second and fourth left inner spaces becomes increasingly evident. Diastolic murmurs are occasionally heard. A venous hum was audible in the pulmonary area in about one-fourth of the cases.

Radiologic examination of the heart is useful in making a diagnosis of anomalous drainage. This is particularly true among the children whose pulmonary veins drain into the left innominate vein. Here there is a characteristic shadow consisting of a wide pulsatile arc on either side of the supracardiac area in the anterior mediastinum. It has been described as forming a figure "8" with the rest of the heart. Usually, however, this diagnostic shadow fails to show up in the first few months of life. Increasing cardiac enlargement after birth is the rule. Lung vascularity is markedly increased. Angiocardiography may occasionally be of distinct value in making the diagnosis.

Catheterization of the heart shows a rise in oxygen content as the right auricle or one of its tributaries is entered. When the origin of the rise is clear, the diagnosis is evident, but occasionally difficulties appear. In early infancy the major problem lies in differentiating cases of aortic hypoplasia or atresia or the infantile type of coarctation.

Surgical correction of the anomaly would seem theoretically possible because of close proximity of the left auricular appendage to the anomalous venous trunk. Several factors, however, militate against successful surgery: the small waist of the left auricular appendage, the difficulty in making a large enough anastomosis, and the small left auricle and ventricle.

Ten figures, including 1 roentgenogram; 4 tables.

HOWARD L. STEINBACH, M.D.
University of California, S. F.

Pulmonary Arterio-Venous Fistula. James Ronald. Brit. Heart J. **16**: 34–38, January 1954.

In pulmonary arteriovenous fistula a proportion of venous blood from the pulmonary artery is shunted to the pulmonary vein without passage through the lung capillaries; venous blood returns to the left side of the heart to mix with arterial blood of the systemic circuit, giving rise to cyanosis, dyspnea, and compensatory polycythemia. The lung has a dual blood supply from pulmonary and bronchial systems, and either or both systems may communicate with the fistula. The part played by each varies; if cyanosis, clubbing, and polycythemia are present, the pulmonary artery and vein are undoubtedly involved. In the absence of cyanosis and polycythemia, the bronchial arteries probably play the prominent part in supplying blood, and the presence of a murmur may also suggest this.

Two cases of pulmonary arteriovenous fistula are reported: one of multiple fistulae occurring in one of identical twins; the other showing clear evidence of disturbance of cardiac rhythm. The illustrations are inadequate—an angiocardiogram in one case and a photograph of the autopsy specimen in the other.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

Spontaneous Thrombosis of the Internal Carotid Artery. Leslie L. Ralph. J. Fac. Radiologists **5**: 210–217, January 1954.

In presenting 13 cases of spontaneous thrombosis of the internal carotid artery, the author points up the fact that precise clinical diagnosis of this condition became possible only with the advent of cerebral angiography. He states that over 100 cases demonstrated angiographically have been reported since 1937.

The usual angiographic feature is a failure of the cerebral vessels to fill in the presence of normal filling of the external carotid system. While this may be due to technical faults, in the author's experience it is more often due to thrombosis of the internal carotid, and he emphasizes the necessity for showing the carotid bifurcation on the first exposure taken after the injection of the contrast medium. The occlusion, when demonstrated, is usually about 1–2 cm. above that point. The contrast medium stops abruptly at the thrombus, with a characteristic conical or rounded termination. Although the thrombosis is usually found near the origin of the artery, another site of predilection is the region of the carotid siphon.

If an injection is made into the opposite carotid artery, there is always some contrast medium which crosses the mid-line into the affected side. This collateral circulation through the anterior communicating artery always fills the anterior cerebral artery, and less commonly the middle cerebral artery on the side of the thrombosis. There is sometimes also an effective collateral circulation *via* the ophthalmic artery from the external carotid of the affected side.

Because of the good collateral circulation to the anterior cerebral artery, the clinical effects of internal carotid thrombosis are usually manifested mainly by neurologic signs of damage in the territory of the middle cerebral artery. The classical "carotid syndrome" (hemiplegia with blindness in the opposite eye), however, occurs in only 10 per cent of cases. The onset of symptoms is usually prolonged, but may be sudden and catastrophic. While cases have been reported in patients from thirteen to seventy-one years of age, the

common age range is between thirty and sixty. The etiology is still somewhat obscure, but atheroma is probably the usual cause.

A table summarizes the findings in the author's 13 cases. Three cases presenting unusual features are reported in somewhat more detail: (1) a case of cerebral edema following sudden onset of thrombosis; (2) an apparently symptomless thrombosis in a case of cerebral hemorrhage; (3) a case in which the thrombosis followed sepsis complicating angiography done by the open method.

In a case presented in the addendum, a complete obstruction to the flow of contrast medium at the carotid bifurcation was attributed to common carotid thrombosis, but at autopsy a completely normal right carotid artery with no trace of thrombosis or atheroma was found. The only explanation in this case appears to be a major arterial spasm which lasted for at least thirty minutes during angiography, closely simulating a thrombosis.

Ten roentgenograms; 1 table.

DAVID E. WHEELER, M.D.
Indiana University

Mediastinal Tumor Simulated by Azygos Phlebectasia. William J. Sayer, Loren F. Parmley, Jr., and John de L. S. Morris. Ann. Int. Med. **40:** 175–182, January 1954.

Pathologic dilatation of the azygos vein, or phlebectasia, results when obstruction of one of the greater venous circuits forces the utilization of this route of collateral circulation. The condition has been reported in association with obstruction of the superior vena cava or the inferior vena cava, portal hypertension, and congestive heart failure.

Azygos phlebectasia may readily simulate mediastinal tumor. Identification of the entity, after discovery of a tumor-like shadow on the roentgenogram, is aided by tomography, special radiographic views in combination with certain respiratory maneuvers, and especially by angiocardiography. The shadow of an azygos vein will increase in size with forced inspiration against a closed glottis (Müller's maneuver) and will decrease during expiration against the closed glottis (Valsalva's maneuver). The angiocardiogram will demonstrate the dilated vein and failure of the contrast substance to enter the heart where there is obstruction of the superior vena cava.

Two cases of azygos phlebectasia are presented. Angiocardiography was not done in the first case because of sensitivity to the contrast medium. A routine chest film revealed rounded shadows in the right mediastinum and kymography showed them to be non-pulsatile. Thoracotomy revealed marked dilatation of the superior vena cava at its junction with the azygos vein. The azygos system of veins was enlarged from the diaphragm to the apex of the lung. No evident obstruction was found to explain the azygos dilatation.

Angiocardiography in the second case revealed the dilatation of the azygos vein and obstruction of the superior vena cava. Thoracotomy disclosed a hard fibrous cord extending from the heart to the second portion of the right subclavian vein subjacent to an anomalous right upper lobe bronchus producing the superior caval obstruction.

Four roentgenograms; 1 photograph.

JOHN F. RIESSER, M.D.
Springfield, Ohio

The Radiological Demonstration of the Azygos and Other Thoraco-Abdominal Veins in the Living. Giulio Tori. Brit. J. Radiol. **27:** 16–22, January 1954.

Because of the speed of passage of substances injected into bone marrow, transosseous phlebography has several useful applications. It has been used to visualize the deep veins of the pelvis after injection into various parts of the pelvic bones. Injection into the sternum reveals the internal mammary veins, and injections into the spinous process of a thoracic vertebra or the posterior segment of a rib will show the intercostal and azygos system. The method is simple, painless, and safe.

A review of the anatomy of the azygos system is given and the technic of injection is outlined. The azygos system has been demonstrated in twenty cases. Clear-cut indications for the use of the method are not yet known, but it shows promise of indicating diseases of the posterior mediastinum, thrombophlebitic processes, compression syndromes of the superior vena cava, and lesions of the vertebral bodies.

Nine illustrations, including 7 roentgenograms.

SYDNEY J. HAWLEY, M.D.
Seattle, Wash.

Intermittent Claudication of the Hip and the Syndrome of Chronic Aorto-Iliac Thrombosis. Victor G. DeWolfe, Fay A. LeFevre, Alfred W. Humphries, Malin B. Shaw, and George S. Phalen. Circulation **9:** 1–16, January 1954.

The syndrome produced by localized arteriosclerosis of the terminal aorta or iliac vessels consists in intermittent claudication (pain, weakness, easy fatigability) in the hip, gluteal region, low back, lower abdomen, thigh, or even the entire lower extremity. The patient is usually a man between forty and sixty years of age without signs of generalized arteriosclerosis and with good nutrition of the legs and feet. Impotence is an occasional complaint but in the authors' experience was rare. Some consider it an integral part of the syndrome (Leriche).

Aortography has proved invaluable as a diagnostic aid. Though not indispensable for recognition of the syndrome, it is necessary for distinguishing between occlusion of the aorta and the iliac arteries. It was performed in 30 of 47 cases of intermittent claudication seen at the Cleveland Clinic in a period of five years. Urokon 70 per cent was used, and injection was done simultaneously through 2 needles, a total of 24 c.c. of the medium being used.

The commonest site of occlusion was found to be one of the common iliac arteries. These were implicated in 16 of the 30 cases. Seven cases had blocks in the terminal aorta varying in location from just below the renal arteries (3 cases) to the bifurcation. Four patients had both common iliac arteries involved, and clinically these patients were indistinguishable from those with aortic occlusions. In this group the aortogram was particularly valuable because the prognosis may be considerably more grave when the aorta is involved. The common iliac artery was involved in combination with the opposite external iliac artery in 1 case.

In general, aortic and common iliac artery occlusions are associated with the most effective collateral circulation. There are two principal collateral channels. One is more laterally placed, consisting of blood from the lumbar arteries passing to and through the "cruciate circulation" of the hip and returning to the femoral

artery or arteries *via* the medial and lateral circumflex femoral arteries. The ascending branches of the medial and lateral circumflex arteries may or may not enter into this system. Of lesser import and frequency, and seen in the lower occlusions (iliac), is a more medially placed anastomosis from the lower lumbar and/or upper sacral arteries, through the obturator artery, to the circumflex femoral arteries and thence to the femoral. Depending on the site of the block, the superior and inferior gluteal vessels and the deep circumflex iliac artery may enter into this system.

As to treatment, the authors are quite conservative at present but hope that eventually resection and grafting will be practical. They regard sympathectomy as only slightly beneficial and have given up endarterectomy after trying it in 3 cases. Follow-up observation of a number of patients in whom no surgical measures were used was interesting. Five were lost to follow-up, 3 became worse, 10 were unchanged, and 11 were improved.

Six roentgenograms; 9 tables.

ZAC F. ENDRESS, M.D.
Pontiac, Mich.

THE BREAST

The Roentgen Differential Diagnosis Between Chronic Mastitis and Breast Carcinoma. Ch. M. Gros and R. Sigrist. Fortschr. a. d. Geb. d. Röntgenstrahlen **80:** 50–65, January 1954. (In German)

The author believes that x-ray studies of the breast have not been given the consideration that they deserve. These studies are to be considered as furnishing contributory evidence and not as a substitute for biopsy. No effort, however, should be spared to assist in establishing the earliest possible diagnosis of carcinoma.

Both lateral and longitudinal projections are made. The factors are: target-film distance 70 cm., 32 to 38 kv., 30 ma., and three to five seconds exposure. For localized areas, the distance is reduced to 10 cm., with 26 to 30 kv., 30 ma., and one to two seconds exposure. The normal breast pattern varies with age, lactation, and relationship to the menstrual cycle. It is recommended that, when possible, studies be made one week after the menstrual period.

In chronic mastitis the two major features are sclerosis and cyst formation. Diffuse sclerotic changes involve the fibrous structures, which are thickened and show increased opacity. Cyst formation is multiple, small and large cysts often being present in the same breast. The large cysts are usually located in the upper outer quadrant and are frequently homogeneous, with no surrounding inflammatory or infiltrative reaction.

Scirrhous carcinoma shows central opacity, with poorly defined, irregular and serrated borders and radiating processes extending outward into the surrounding tissue. Frequently thickening and edema of the skin are associated. The area of involvement observed radiologically is always smaller than that determined by palpation or visualized in the operative specimen. The opacity is not homogeneous and frequently irregular calcium deposits are seen.

The encephaloid carcinoma, frequently found in the senile breast, may be fairly clearly differentiated from the surrounding normal tissue. Contrast is usually good. Fewer extensions into the breast tissue are observed and the general pattern is irregularly round or oval. The remaining breast tissue is normal. Calcium deposits are frequently observed.

The author believes that with sufficient experience, the radiologist may very definitely contribute toward the diagnosis of early breast carcinoma.

Twenty-seven illustrations.

E. W. SPACKMAN, M.D.
Fort Worth, Texas

THE DIGESTIVE SYSTEM

Lesions of the Esophagus in Infants and Children. Edward B. Singleton. Texas State J. Med. **49:** 855–860, December 1953.

Lesions of the esophagus are somewhat uncommon, but their diagnosis is important because the majority are surgically curable. Ingested foreign bodies and cicatricial changes in the esophagus due to caustics are the most common abnormalities seen by the pediatrician and radiologist. The purpose of this report is to call attention to less common abnormalities, both acquired and congenital in origin, which may present difficulties in diagnosis.

Esophageal atresia with or without fistulous communication with the trachea is the most commonly encountered congenital abnormality. Rapid serial exposures of the esophagus during deglutition offer a reliable method of studying the function of the esophagus and the patency of the site of anastomosis after surgical repair. The majority of the follow-up examinations disclose lack of motility of the esophagus, which probably is the result of interference with the autonomic innervation at the time of surgery, though congenital absence of the normal innervation is possible. This lack of motility does not appreciably handicap the patient. A single case is described, in which serial films made nine years after operation show the site of anastomosis as well as the interference with motility.

Tracheo-esophageal fistula without atresia of the esophagus is rare, but should be considered in infants with choking attacks during feeding. The fistula, which is usually small, may follow an oblique course caudally, from the trachea to the esophagus and consequently may be demonstrable only with the infant in the Trendelenburg position.

Congenital stenosis of the esophagus is also extremely rare and often impossible to differentiate from an inflammatory stricture. In this condition, it is necessary to use contrast material in the examination, rather than simply noting the level at which the obstruction to a rubber catheter is encountered. The mid-portion of the esophagus is usually the site of congenital stenosis, whereas inflammatory stricture secondary to peptic ulceration usually affects the lower third.

Esophageal duplication may produce classic signs and symptoms of an expanding intrathoracic lesion or the anomalous structure may attain a large size before clinical symptoms occur. Because anomalies of the thoracic spine are frequently associated with esophageal duplication, differentiation from anterior meningocele may be impossible without myelography. Communication of the duplicated segment with the esophagus is seldom present.

Cardiospasm or achalasia of the esophagus is an acquired abnormality, the etiology of which is not definitely known. The history, as well as the abrupt change from dilated to stenotic esophagus, helps in differentiating the condition from caustic stricture.

Chalasia of the esophagus is one of the causes of persistent regurgitation of feedings in the newborn and young infant. In this condition, there is persistent relaxation at the cardio-esophageal junction, thereby allowing gastric contents to enter the esophagus. A case is shown of a six-month-old infant who had failed to gain satisfactorily since birth and who had regurgitated practically all of each feeding. During fluoroscopy, the downward excursion of the diaphragm during inspiration resulted in propulsion of the contrast material from the stomach into the esophagus, promptly followed by regurgitation. Feeding in the upright position resulted in more adequate retention of the contrast material in the stomach.

Congenitally short esophagus with associated hiatus hernia is probably rare. The general concept now is that in most instances the esophagus becomes shortened as a result of peptic ulceration secondary to heterotopic gastric mucosa within the esophageal wall. In other cases, the short esophagus may result from esophageal ulceration secondary to a congenital hiatus hernia. In these cases, gastric juice reaches the esophagus through an incompetent esophageal hiatus and the chronicity of the process leads to ulceration.

Anomalous development of the vessels arising from the aortic arch not infrequently results in pressure deformities of the esophagus of sufficient degree to produce dysphagia. The most common anomaly is the ectopic right subclavian artery, which passes either posterior or anterior to the esophagus, producing an oblique defect. The second most common is the double aortic arch or vascular ring, which becomes more constrictive as the infant increases in size.

Twenty roentgenograms; 2 drawings.

C. R. PERRYMAN, M.D.
Pittsburgh, Penna.

Radiologic Aspects of the Inferior Esophagus: The Phrenic Ampulla and the Cardiac Antrum. D. Catalano. Radiol. med. (Milan) **40:** 11–19, January 1954. (In Italian)

The consensus is that the distal esophagus is comprised of two anatomico-functional segments, one above and one below the diaphragm. The former, called the epiphrenic bell, phrenic ampulla, *Vormagen*, etc., is best demonstrated when the patient is supine, and during the Valsalva maneuver. It must be differentiated from sliding hiatal hernia and gastroesophageal reflux. The segment below the diaphragm, the cardiac antrum, is less well defined. Indeed, its existence is even doubted by some. Others say that it is a part of the stomach and corresponds to the anterior stomach of the ruminants.

Lerche (The Esophagus and Pharynx in Action. Springfield, Ill., Charles C Thomas, 1950), after a careful anatomico-functional study, concluded that there was a morphologic and functional unit between the esophagus and stomach, which he called the gastro-esophageal segment of expulsion. This segment is constituted proximally by the phrenic ampulla (situated above the diaphragm and limited below by the inferior esophageal sphincter, which is constantly in tonic contraction, except at the moment of passage of ingesta) and distally by the gastroesophageal vestibule (situated below the diaphragm and bounded by the inferior esophageal sphincter above and the constrictor of the cardia below). According to another school of thought, it is the action of the diaphragm upon the esophagus that is of importance; there is no sphincter in the esophagus at this level, but the esophageal canal is compressed by action of the right diaphragmatic crus.

The author's concept is that there is a narrowing of the esophageal lumen at the level of the diaphragm, independent of the action of the latter. This was demonstrated in the cadaver by graduated filling of the lower esophagus after ligation of the cardia. The dilatation that occurred between the narrowing and the cardia represents the cardiac antrum. The diaphragm exerts its effect not only by modifying the hiatus but also by the variations in pressure between the thoracic and abdominal cavities produced by its movement.

When the cardiac antrum shows maximal distention, it is rounded with smooth margins and with an axis identical to the epidiaphragmatic esophagus. When the distention is less, the antrum is conical, with the base proximally at the level of the diaphragmatic narrowing and the apex at the cardia. More often it appears tubular. In roentgenograms, it has a length of 1.5 to 2 cm. and is directed obliquely from above below, anterolaterally, to end at the cardia. It is best visualized in expiration and with the patient supine or in the Trendelenburg position.

While the antrum is to be regarded primarily as infradiaphragmatic, it is possible to see a part of it above the diaphragm. This protrusion (which has no pathologic significance), together with the phrenic ampulla, forms a picture that is likened to Saturn's rings. The external ring is formed by the proximal end of the cardiac antrum, the central density represents the phrenic ampulla, and the transparent ring between the two is attributable to excessive mucosa.

Twenty-one roentgenograms; 1 drawing.

CHRISTIAN V. CIMMINO, M.D.
Fredericksburg, Va.

On the Diagnosis of Malignant Lymphoma of the Gastrointestinal Tract. Edwin L. Lame, Clarence A. Velat, and R. Philip Custer. Ann. Int. Med. **40:** 57–74, January 1954.

The possibility of malignant lymphoma of the gastrointestinal tract must be considered regularly in the critical appraisal of gastrointestinal lesions. At the Presbyterian Hospital in Philadelphia, during the period 1947–51, these tumors comprised 20 per cent of the malignant tumors of the stomach found at operation (national average, 2–3 per cent) and about half of those removed from the small bowel. Lymphomas of the colon were numerically and proportionately low in incidence.

The authors regard malignant lymphoma as a single neoplastic entity, including the following types: follicular, lymphocytic, reticulum-cell, and Hodgkin's. They report a series of 22 cases.

Roentgen examination is of primary importance in locating the source of trouble when these lesions occur in the stomach. It is usually successful in labeling the lesion as malignant, but differentiation from carcinoma is seldom possible. Roentgenograms illustrating lymphoma, carcinoma, and chronic gastritis are reproduced, which are virtually interchangeable. In the presence of a large, angry-looking tumor of the stomach, however, as demonstrated by the films, with epigastric pain, anorexia, nausea, and vomiting, without signs of obstruction, moderate weight loss and little or no anemia, there should be a strong suspicion of lymphoma.

Lymphomas of the small intestine may be single or

multiple, small or large, discrete or diffuse. In some the roentgen study may suggest a tumor; others are seen as nondescript, infiltrative lesions, resembling an inflammatory enteritis, or produce a picture similar to a nutritional disturbance or diffuse peritoneal irritation. Especially troublesome are bowel lesions created by adherent lymphomatous nodal masses, but physical examination is often valuable in disclosing these enlargements.

Three lymphomas of the colon were seen in this series. One presented as a localized mass at the hepatic flexure, while the other 2 were diffuse, infiltrative, non-obstructive lesions. Lymphomas of the colon usually occur in the cecum or rectum.

If a tumor found at operation is unresectable, the surgeon should remove a portion of the main mass for pathologic study, as many of the neighboring nodes will show only reactive changes. Frozen section is unreliable. A definitive diagnosis should always be made, so that radiotherapy or chemotherapy may be instituted.

Thirty-one roentgenograms; 1 diagram; 3 tables.

JOHN F. RIESSER, M.D.
Springfield, Ohio

Anatomy of the Pyloric Canal and the Etiology of Infantile Pyloric Stenosis. Johan Torgersen. Am. J. Roentgenol. **71**: 76–80, January 1954.

Anatomical studies have shown the structure of the pyloric canal in man and several animals to be analogous. This segment of the stomach is composed of two sphincters, one at the oral portion of the canal and the other at the aboral position. The aboral sphincter corresponds roentgenologically to the pyloric sphincter and consists of both gastric and duodenal parts.

Torgersen believes that the "situs" of a viscus depends upon a complex of genes, which may be broken. He cites Pernkopf as describing two cases of gastric inversion, each without evidence of a pyloric sphincter. These cases are believed to "represent a counterpoint to infantile pyloric stenosis" and to "confirm the supposition that the embryonic topography is a decisive factor in the development of the pyloric canal and in infantile pyloric stenosis."

Three roentgenograms; 4 drawings.

M. HARLAN JOHNSTON, M.D.
Jacksonville, Fla.

Pyloric Obstruction in Peptic Ulcer. Harold P. Roth and Daniel Liebowitz. Ann. Int. Med. **40**: 11–25, January 1954.

Gastric retention in peptic ulcer is usually due to narrowing at the pylorus or in the duodenum. Both are referred to as pyloric obstruction. The narrowing may be caused by spasm and edema secondary to an active ulcer, scar tissue formed in the healing of an ulcer, or a combination of these factors.

Eighty-seven cases of peptic ulcer with gastric retention seen consecutively in the Veterans Administration Hospital, Cleveland, between July 1946 and October 1951, were studied. Those patients were considered to have gastric retention who had either retention of barium at six hours or, on morning aspiration, had over 100 c.c. of fluid or retained food in the stomach. Data on 83 such patients are reviewed here, 4 having been lost to follow-up.

Once it was decided that there was evidence of pyloric obstruction, the patient was placed on a medical regimen of frequent bland feedings and aspirations to relieve gastric retention. Forty-four patients responded initially but, at or before follow-up, gastric retention had recurred in 16. Retention usually cleared within a week from the beginning of medical therapy in those who did not have a recurrence. A longer period before improvement usually indicated a subsequent recurrence.

Certain elements in the history and initial laboratory studies gave an indication of organic obstruction or scarring; other features tended to support a diagnosis of retention secondary to spasm and edema. Patients with organic obstruction were older, had a longer history of ulcer, and more frequent hospitalizations. Their pain was often not alleviated by antacids, was frequently made worse by eating, and was relieved by vomiting. They usually had a long history of vomiting of material containing retained food. Many had previous perforations or previous treatment for obstruction. They usually showed greater degrees of retention of barium and larger gastric residue.

Fifty patients ultimately were operated upon, 39 during their first hospitalization and 11 at a later admission. Thirty-eight were found to have a definite narrowing in either the duodenum or the pylorus. In 10 of these only a probe could be passed through the area. Twelve of the remaining 28 had active ulcers in spite of previous medical therapy. In view of this observation, obstruction, in the duodenum at least, may be said frequently to be due to a combination of moderate narrowing due to scarring and further narrowing due to edema and spasm secondary to an active ulcer.

Six tables.

JOHN F. RIESSER, M.D.
Springfield, Ohio

Perforated Peptic Ulcer in the Newborn: Report of a Case with Massive Bleeding. William H. Moncrief, Jr. Ann. Surg. **139**: 99–102, January 1954.

A case of bleeding peptic ulcer with perforation in a newborn infant, with recovery, is reported. Forty-eight hours after birth, the child vomited some "coffee ground" material. A roentgenogram of the abdomen showed a moderate amount of gas in the stomach and one or more dilated loops of bowel in the left side of the abdomen. A pneumoperitoneum was also present. Shortly thereafter, the infant vomited 65 c.c. of bright red blood. Surgical exploration was carried out, and a 7-mm. perforation on the anterior wall of the duodenal cap was repaired.

The etiology of peptic ulceration in infancy and in the newborn is unknown, but many of the adult factors probably pertain to the very young. There appears to be some relationship between difficult labor with intracranial damage and peptic ulceration. In the newborn, ulcers are of the acute type with little if any surrounding inflammatory reaction. The diagnosis is usually made only when hemorrhage or perforation occurs.

Two roentgenograms.

DEAN W. GEHEBER, M.D.
Baton Rouge, La.

The Roentgen Diagnosis of Erosive Gastritis. W. Abel. Fortschr. a. d. Geb. d. Röntgenstrahlen **80**: 39–50, January 1954. (In German)

Gastroscopy has previously been the accepted method

of choice in the diagnosis of erosive gastritis because of the superficial nature of the erosions. With the more recent technics, the author believes that x-ray diagnosis is possible and definitely contributes to the recognition of the condition.

Perfect dark adaptation is necessary for fluoroscopy. A relatively dry stomach and exacting technic are required. Unibaryt B or C was used by the author as contrast material. Small amounts were given, fractionating the dose to show optimal contrast and the fine details of the mucosal folds. Varying degrees of compression were used and film exposures were guided by the fluoroscopic findings. Of 389 patients with gastric or duodenal ulcers, 10 per cent showed associated erosive gastritis.

In the acute stage, which may be quite superficial with extensive leukocytic infiltration, there is little or no x-ray evidence, and the only changes noted are usually in the antral region. The subacute form, with less leukocyte infiltration and more exudative reaction, presents erosive changes which, although not prominent, may be recognized by x-ray. The chronic stage shows deep erosions with granulations and fibrotic changes. In a single operative specimen, one may observe acute and chronic changes, areas of hypertrophy and erosion with scarring and evidence of healing. The author believes that the erosions may constitute a background factor in ulcer development and that the chronic changes may be the basis for later carcinoma.

The erosions are usually more or less regularly rounded or oval with hypertrophic borders. Superficial mucosal erosions may be elongated and irregular. Small ulcers are indicated by a central barium-filled niche and a clear surrounding zone. On heavy compression, this clear zone disappears, indicating that it is edematous or inflammatory in nature. Fine granulations and polypoid formations are frequently recognized, appearing more prominent under heavy compression.

Under conservative therapy, the author has observed complete healing in the acute and subacute stages, but more or less permanent change results from the chronic stage.

Eleven roentgenograms; 1 photograph.

E. W. SPACKMAN, M.D.
Fort Worth, Texas

Cancer of the Stomach with Long Survival After Operation, and Its Early Diagnosis. Hans Heinrich Berg. Radiol. clin. **23:** 1–4, January 1954. (In German)

This short report deals with 7 patients surviving for relatively long periods after operation for cancer of the stomach, in spite of delay in diagnosis, for as much as three years in one instance. The survival times ranged from three to eighteen years, and the patients were in most of the cases symptom-free, though some of the group were found at operation to have definite lymph node involvement. The author advises that, although early diagnosis is of course worth while, it should not be forgotten that even without a so-called early diagnosis a long survival time after surgery is possible. Under rare conditions, this may occur even when metastases are left in the abdomen. The diagnosis of inoperability is therefore unsafe for prognosis. It is suggested that we study the nature of the biologic defenses of the body against malignant disease more than we have in the past.

CHRISTIAN V. CIMMINO, M.D.
Fredericksburg, Va.

Congenital Intrinsic Obstruction of the Duodenum, with Report of Three Cases. Wallace A. Arneson and Charles W. Ihle, Jr. Ann. Surg. **139:** 95–98, January 1954.

The authors feel that, although duodenal atresia and stenosis are rare, the malformation is more prevalent than previously supposed. Its detection requires only alertness on the part of the examining physician, as the diagnosis can be definitely established by the triad of persistent vomiting soon after birth, upper abdominal distention, and a characteristic roentgenogram.

In atresias, survey roentgenograms of the abdomen will show gas in the stomach and duodenum with no gas in the remaining intestinal tract. In a duodenal stenosis, some gas will appear distally, as the obstruction is incomplete. If doubt still exists after the survey roentgenograms, the diagnosis can be confirmed by instilling thin barium into the stomach through a catheter.

The 3 cases reported were treated successfully by surgery. Early diagnosis with prompt surgical correction should give a high percentage of cures.

Three roentgenograms; 1 photograph.

DEAN W. GEHEBER, M.D.
Baton Rouge, La.

Simultaneous Sigmoidoscopy and Barium Enema. Sydney Jampel, Stephen Dewing, and Harold G. Jacobson. J.A.M.A. **154:** 121–123, Jan. 9, 1954.

The barium enema study and sigmoidoscopy have overlapping and supplementary spheres of applicability. Both procedures are useful in the study of idiopathic ulcerative colitis, in 95 per cent of cases of which the rectum and lower sigmoid are involved. Also, 60 to 75 per cent of colonic tumors occur in areas accessible to the sigmoidoscope.

Eleven patients consented to receive the two examinations at one "sitting." Rectal examination and sigmoidoscopy were first performed by the proctologist with the patient in the Sims' position on a horizontal fluoroscopy table. The sigmoidoscope was passed at least to the rectosigmoid junction (10–18 cm.), and in most instances for its entire length (25 cm.). Air inflation was used as needed. The patients then were directed and assisted in turning slowly to a supine position, with the sigmoidoscope still in position. The light carrier was removed from the sigmoidoscope and replaced by a perforated rubber stopper through which a tube carried the fluid from an enema can, and a barium enema was administered through the sigmoidoscope by the radiologist.

This combined procedure is believed to offer definite advantages. The discomfort that the patient experienced was thought to be less than the total discomfort of the two examinations performed separately. A single preparation with laxatives and cleansing enemas suffices. The greater amount of time required for the combined examination is acknowledged to be a possible disadvantage. Biopsies should not be attempted through the sigmoidoscope if a barium enema is to follow.

Four roentgenograms. ARTHUR S. TUCKER, M.D.
Cleveland Clinic

Familial Cancer of the Colon. Milton W. Durham. West. J. Surg. **62:** 26–31, January 1954.

Of 29 members of a family who were traced, 18 had

familial polyposis or carcinoma of the colon; case histories of 5 of the 18 are presented. The surgical treatment of such cases is reviewed with special emphasis on the feasibility of one-stage total colectomy with permanent ileostomy in patients with frank carcinoma. In those patients without evidence of carcinomatous change a one-stage ileoproctostomy is suitable, but these patients should be examined every six months for possible malignant change. If carcinoma develops, a permanent ileostomy may be made with abdominoperineal resection of the rectal segment.

The necessity of adequate examination of all siblings in cases of familial polyposis is re-emphasized.

One roentgenogram; 2 photographs; 2 charts.

R. F. LEWIS, M.D.
Cleveland Clinic

Leiomyoma and Leiomyosarcoma of the Colon. Donald A. MacKenzie, John R. McDonald, and John M. Waugh. Ann. Surg. **139:** 67–75, January 1954.

Smooth muscle tumors of the colon are extremely rare, only 10 leiomyosarcomas (including the 5 added in this report) and 27 leiomyomas (including the 9 added in this report) being recorded. These tumors have been classified into four groups on the basis of their gross characteristics: (1) intracolic, (2) extracolic, (3) circumferential, and (4) "dumb-bell" tumors.

The roentgenographic findings have differed in the four types of tumors. In the intracolic type, the lesion usually was visualized as a polypoid filling defect. In some of the cases an associated intussusception was found at the time of surgery but was not demonstrated on the roentgenograms.

The findings in the extracolic type of tumor were not uniform. In one instance, a deep cavity was present which communicated with the lumen of the bowel. This represented cavitation formed by degeneration within the central area of the neoplasm.

The roentgenographic findings were described in 3 cases of the circumferential type of tumor. In one, an 8 cm. narrowing of the bowel lumen was present, which was not distensible. In another, the tumor gave the appearance of an intramural mass with preservation of the mucosal pattern. Surprisingly, in one instance, the appearance was suggestive of a diverticulitis.

Roentgenographic findings were available in only one of the "dumb-bell" type tumors. A polypoid tumor could be seen in the bowel lumen, continuous with a dense region outside the lumen which exerted extrinsic pressure on the colon.

Surgical removal is considered the treatment of choice. Roentgen therapy has not been used in a sufficient number of cases to determine its effectiveness.

Two tables.

DEAN W. GEHEBER, M.D.
Baton Rouge, La.

Roentgen Manifestations of Lipoma of Colon. Aristide Rollandi. Riv. ital. radiol. clin. **3:** 181–193, October-November-December 1953. (In Italian)

The radiologic diagnosis of benign tumor of the colon is based upon the presence of a filling defect which is usually round, with a regular and smooth contour. The elasticity and motility of the viscus are unaltered.

The author mentions the paradoxical behavior of these lesions after examination with a barium enema and the barium meal. It is possible that the tumor, well visualized after a contrast enema, may not produce any filling defect when barium is given by mouth. Obviously the benign growth does not infiltrate the intestinal wall and does not produce morphological changes in the intrinsic or extrinsic nervous plexuses. The colonic function is unaltered, and the viscus is able to contract without alteration of the haustra, despite the presence of the tumor. A lipoma *never* infiltrates the muscle coat. If it is subserosal, the muscular contraction pushes it away from the barium-containing lumen and, after a barium meal, no filling defect is demonstrated. If the lipoma is submucosal, there may exist some chance of encroachment on the contrast medium, but the mass is *always* separated from the lumen by the width of the mucosa. After a barium enema (a somewhat unphysiological method of investigation) the colonic wall behaves rather passively, and therefore even a relatively small change in intestinal caliber can be demonstrated radiologically. The multilobular appearance of the filling defect produced by the lipoma is another important diagnostic feature.

A case is reported in which an incorrect diagnosis was made preoperatively. The clinical signs and symptoms of the benign tumors of the colon are also listed.

Five roentgenograms; 1 photomicrograph; 1 photograph.

R. G. OLIVETTI, M.D.
Newington, Conn.

Polyps of the Rectum and Colon in Children. Reynold Erskine Church and A. David Schwartz. J. Pediat. **44:** 104–111, January 1954.

The authors believe that rectal polyps and redundancy of the lower portion of the large bowel are far more common in children than is generally appreciated. They present no statistics of their own but state that they see approximately 6 cases of polyps each year and many more of extreme bowel redundancy.

Anatomical observations have revealed a marked mucosal redundancy of the sigmoid and rectum associated with single polyps. This may be so marked that a polyp of the sigmoid easily protrudes through the anus. The authors believe that chronic constipation and faulty bowel habits with constant straining at stool may be the etiological agents of the redundancy and that from or on the redundant mucosa the polyp develops. Removal of the primary factor with the polyp is usually followed by shrinking or disappearance of the redundancy.

Bleeding is the most frequent symptom. Protrusion of a mass through the anus is often the first indication of a polyp. Abdominal discomfort is not a common complaint. The diagnosis is most frequently established by digital examination associated with a visual noting of the size and character of the polyp or by proctoscopic examination. This should always be followed by roentgen examination. When the bowel is filled with contrast medium, the polyps appear as circular filling defects. They project into the lumen rather than distorting the contour of the bowel outline.

HOWARD L. STEINBACH, M.D.
University of California, S. F

Primary Megacolon in Young Adults. Francis W. Wilson. Am. J. Digest. Dis. **21:** 4–9, January 1954.

Primary megacolon was diagnosed in 11 young adults. In all, symptoms were mild, consisting usually in chronic constipation. The functional nature of the disease was proved by a lack of obstructive findings on rectal,

proctoscopic, and roentgenographic examinations. Dilated, air-filled colon seen on a routine chest film in 9 of these patients was suggestive of megacolon.

Thirteen roentgenograms.

RICHARD E. BUENGER, M.D.
Chicago, Ill.

Volvulus of the Cecum. William Brock. West. J. Surg. **62**: 12–17, January 1954.

Five cases of volvulus of the cecum are presented. The reported incidence ranges from 1 to about 12 per cent of all intestinal obstructions. Of all cases of volvulus, the cecal variety is said to account for approximately 10 per cent.

According to the reports in the literature, volvulus of the cecum occurs most frequently in patients from twenty to fifty years of age, and predominantly in men. Of the author's 5 patients, 4 were women and 4 were more than fifty years old.

Anatomical studies have shown that in 10 to 20 per cent of adults fixation of the cecum and terminal ileum is inadequate, predisposing to volvulus. The clinical picture and treatment of the condition are discussed.

The necessity for roentgenologic examination for diagnosis is stressed. The diagnosis can usually be suspected from the supine and upright films. In all cases a large gas-filled loop of large bowel, generally with a single fluid level, is seen. This has been said to be typically in the left upper quadrant, but it may be in the left upper quadrant, the mid-abdomen, the right lower quadrant or, in the event of complete non-rotation, even in the left lower quadrant. If the dilated cecum is in an ectopic position, an absence of gas-filled cecum and right colon in the usual position will be noted, and small bowel will be seen to the right of the dilated loop. Varying degrees of small bowel distention will be observed. If a barium enema study is done, the barium column will usually terminate in the ascending colon.

Five roentgenograms; 1 table.

R. F. LEWIS, M.D.
Cleveland Clinic

Meckel's Diverticulum. Robert D. Sloan, Edward S. Stafford, Martin L. Singewald, and Charles M. Sinn. Am. J. Roentgenol. **71**: 64–75, January 1954.

Meckel's diverticulum is a congenital malformation occurring as the result of failure of closure of the distal segment of the vitelline duct. Autopsy experience has shown that it is present in 1 to 2 per cent of examinations. In 10,000 consecutive autopsies at the Johns Hopkins Hospital, 103 diverticula were found. In none of these cases was the diverticulum known to be of clinical significance.

Meckel's diverticula become clinically important when one of the following complications occurs: intestinal obstruction, intussusception, hemorrhage, acute inflammation with or without perforation. The diverticulum frequently contains aberrant gastric mucosa, accounting for cases of ulceration with hemorrhage or perforation. Of less frequent occurrence are benign or malignant tumors, perforation by a foreign body, tuberculosis, or regional enteritis. Calculi have occasionally been visualized, but are of no known clinical significance.

Nineteen cases of clinically significant Meckel's diverticulum were seen at the Johns Hopkins Hospital in a twenty-year period. In only 7 of these were contrast roentgen studies undertaken, in the form of a small intestinal series or a barium enema examination. In 5 of the 7 cases hemorrhage was the predominant clinical feature. In the remaining 2 cases intussusception was present and emergency barium enemas were given for therapeutic as well as diagnostic purposes. In none of the 5 cases in which the terminal ileum was visualized was the diverticulum identified. The cases complicated by obstruction and acute inflammation were regarded as surgical emergencies, and in these roentgenography was not attempted.

A review of the literature revealed only 22 cases in which a proved Meckel's diverticulum was demonstrated roentgenologically. The probable explanation of the infrequency of demonstration is that the average Meckel's diverticulum, with its relatively short length, wide ostium, and a lumen diameter comparable to the adjacent small intestine, cannot by ordinary methods be differentiated from adjacent small intestinal loops.

Nine roentgenograms; 2 photographs; 4 tables.

M. HARLAN JOHNSTON, M.D.
Jacksonville, Fla.

Metastatic Carcinoma of Rectum to the Thyroid Gland: Correlation with Radioactive Iodine Studies. David M. Sklaroff. Arch. Surg. **68**: 117–119, January 1954.

Metastatic tumors are only infrequently found in the thyroid gland. This may be due to the fact that the thyroid is seldom examined at a routine autopsy. Metastatic carcinoma from the rectum to the thyroid gland is very rare, only a few cases having been recorded.

A 73-year-old woman was observed by the author in 1952, seven years after an abdominoperineal resection for adenocarcinoma of the rectum. She reported that she had had a goiter for fifty years. Examination revealed discrete masses in both lobes of the thyroid. Studies with radioactive iodine revealed normal thyroid retention, liver retention, and urinary excretion of the isotope. Chest roentgenograms failed to reveal any evidence of metastasis or of substernal extension.

The patient complained of dyspnea and this became increasingly severe. An emergency tracheotomy became necessary, and during the procedure death occurred. Autopsy revealed metastatic adenocarcinoma of the rectum in the thyroid gland and the isthmus. No other evidence of metastasis was found.

Three thyroid retention curves.

JOHN F. RIESSER, M.D.
Springfield, Ohio

A New Volumetric Method for Measuring Gallbladder Contraction After a Fatty Meal. C. Wieser. Schweiz. med. Wchnschr. **84**: 149–153, Jan. 23, 1954. (In French)

The author describes a method of measuring the contraction of the gallbladder following a fat meal, which has the advantage of being simple and at the same time sufficiently precise for clinical needs. The only projections needed are the frontal and lateral. These are made in succession without moving the patient. The accuracy of the method was proved with the use of models. This bidimensional method of gallbladder examination not only gives details of function not possible with ordinary cholecystography, but also morphologic detail.

The application of the method is easy: after having traced the gallbladder image on a transparent paper ruled off in millimeters, one can measure the surface with the aid of a planimeter, or even count the number of squares, or lastly, cut out the paper tracing and weigh it on a precision balance (since the weight of a square centimeter of the paper is known, the exact area can be determined provided the paper is homogeneous).

The author has prepared a nomogram whose two co-ordinates represent the frontal and lateral surface areas of the projected gallbladder, and from which the volume can be read directly. The differences in the volumes before and after the fatty meal, divided by the initial volume, multiplied by 100, gives the per cent evacuation. This whole operation can be done in less than ten minutes.

[For some comments on the significance of contraction of the gallbladder after a fatty meal, the reader is referred to Shapiro: Cholecystography, a Critical Review. Radiology **62**: 245–247, 1954.—C. V. C.]

Six figures; 1 table.

CHRISTIAN V. CIMMINO, M.D.
Fredericksburg, Va.

THE MUSCULOSKELETAL SYSTEM

Osteopetrosis. Samuel Kleinberg. Am. J. Surg. **87**: 50–62, January 1954.

With the report of 2 cases, the author presents a general discussion and history of the development of our knowledge of the disease entity known as osteopetrosis. There are numerous synonyms for the condition: marble bones, chalky bones, congenital osteosclerosis, osteosclerotic anemia, and osteopetrosis.

Osteopetrosis affects the white and colored races, both sexes, and all age groups. It may exist in any stage from mild to very severe. The most severe or malignant form occurs usually in infants; the milder form is found in older children or adults. The predominant finding in all cases is sclerosis of the bones. In the severe cases, this may result in a number of secondary symptoms, such as anemia resulting from encroachment upon the marrow spaces. In the cranium, the bones of the base are chiefly involved and there may be encroachment upon the cranial nerve foramina, causing such symptoms as blindness, facial palsy, etc. Many cases are diagnosed at the time of a fracture or on routine roentgenograms made for some other reason. Mild cases may show similar symptoms, but to a lesser degree. The cause of the disease is as yet undetermined. It is seemingly a disturbance of the development of metabolism of bone. Records show a familial tendency.

The cases presented here were both of the mild type. The first patient, a thirty-five-year-old man, was admitted for a fracture of the proximal shaft of the femur. Routine roentgenograms disclosed increased sclerosis of the femur and the pelvic bones. Healing was delayed, and even after fifteen months, when union appeared to be solid and the patient was allowed to walk, the metal plate broke and there was some angulation at the fracture site. No pain or significant deformity was associated with the mishap. Laboratory findings in this case were essentially normal. The second case was that of a boy first seen at sixteen years because of very short stature and bilateral bowing of the femora. Roentgen findings demonstrated extensive osteosclerosis and blood studies were relatively normal. The bowing was partially corrected by means of osteotomies, which healed readily. The rapid healing in this case is in interesting contrast to the delayed healing in the first case presented. This patient also had involvement of the spine, with marked scoliosis.

Seventeen roentgenograms; 3 photomicrographs.

ALLIE WOOLFOLK, M.D.
Pittsburgh, Penna.

Subarticular Pseudocysts in Rheumatoid Arthritis. B. Cruickshank, J. G. Macleod, and W. S. Shearer. J. Fac. Radiologists **5**: 218–226, January 1954.

Patients with rheumatoid arthritis frequently have radiographically demonstrable local areas of loss of substance in subarticular bone, which are often misinterpreted as indicating a vague type of chronic arthritis or gouty arthritis. The authors point out that the occurrence of these "cystic" lesions in rheumatoid arthritis is typical of the disease and they attempt to clarify the underlying pathological processes.

Well defined areas of local destruction of subarticular bone are seen in all stages of rheumatoid arthritis and may be one of its earliest roentgenographic manifestations. They occur frequently near the chrondro-osseous margins and commonly in the heads of the metacarpals and metatarsals, or heads or bases of the phalanges, but may also be observed throughout the carpus or in relation to major joints. The lesions vary from 1 mm. to several centimeters in diameter. In the early stages, the margins are well defined, but there is no sclerosis of surrounding bone. In later stages and in the quiescent phase, the cystic areas may have a definite sclerotic margin, resembling radiographically the punched-out areas of gout or the cystic areas of degeneration seen in osteoarthritis. They may be seen in association with periarticular swelling before there is any evident loss of joint space. Progress roentgenograms demonstrate no healing or resolution of these "cysts."

The pathologic aspects of these lesions were studied by examining material from single joints in 9 cases. In the earlier stages granulation tissue was seen extending from the surface of the articulating cartilage through a defect in the subchondral bone into the adjacent marrow spaces. In the marrow space there was osteoclastic destruction of the trabeculae. The granulation tissue spaces contained moderate numbers of lymphocytes and plasma cells. Apart from the osteoclasts, the histologic appearances in the bone marrow spaces were the same as were seen in the synovial tissues of the same joint. In some of the larger lesions of considerable duration there was ischemic necrosis of the granulation tissue. Pseudocysts in the subarticular bone large enough to be detected radiographically were not encountered in the absence of a connection between the bony lesion and the surface of the articular cartilage.

The lesions are not specific for rheumatoid arthritis. Similar lesions have been described in hemophilic arthrosis, Charcot's joint, syphilitic arthritis, and in gout. In the latter instance the only difference is the presence of urates in the areas of destruction.

The authors suggest the term "subarticular pseudocysts" for these lesions.

Fourteen roentgenograms; 10 photomicrographs.

D. PETERSON, M.D.
Indiana University

The Value of Radiology in the Diagnosis and Management of Pyogenic Osteitis in Childhood. G. A. Neligan and C. K. Warrick. J. Fac. Radiologists **5**: 112–120, October 1953.

The authors discuss the roentgen findings of pyogenic osteitis in children as seen in 103 acute and 4 chronic cases. From the discussion it would appear that in severe acute osteitis in older children the clinical findings are considered of greater diagnostic importance than the radiologic findings, the latter usually appearing after therapy has been started and merely confirming the previous diagnosis. In the newborn, the clinical diagnosis is more difficult, and roentgenography is accordingly of greater usefulness. In 11 of 13 cases in the present series bone changes were evident on the initial film.

In all except 2 cases of this series roentgenographic changes eventually developed in spite of antibiotic therapy. The very early administration of penicillin did not seem to prevent these changes since 2 patients treated at eight and twelve hours after onset subsequently showed roentgen evidence of osteitis.

One of the major points made in the paper is the value of the roentgenograms in determining the proper time to allow resumption of activity. This was usually taken as the time at which the process of progressive decalcification ceased and recalcification was apparent, although in some cases of a more severe nature resumption of activity was delayed until a considerable amount of recalcification had occurred.

Eleven roentgenograms.

MAURICE TATELMAN, M.D.
Detroit, Mich.

Myelomata of Bone. A Review of 25 Cases. A. Naylor and F. E. Chester-Williams. Brit. M. J. **1**: 120–124, Jan. 16, 1954.

Myeloma, generally believed to be a relatively rare lesion of bone, is actually, in the experience of the Bradford Regional Radium Institute, a more common lesion than osteogenic sarcoma. During a five-year period, 24 cases of myeloma were seen at this institution and only 13 cases of osteogenic sarcoma.

The authors find the disease to exist in three forms: (1) the solitary form, presenting a single large tumor; (2) a diffuse form, in which the lesions are small and cause a diffuse decalcification of bone; (3) the multiple form, in which plasma cells aggregate forming the classical localized osteolytic lesions. They believe these three forms to be merely stages of one disease, representing the progression from a localized primary lesion to a generalized metastatic myelomatosis in the same manner as the development of carcinomatosis. Early diagnosis is difficult, since the condition is often asymptomatic for a long period.

Twenty-five case abstracts are presented according to the classification given. The initial solitary lesions tended to show progression to the multiple form. The cases illustrating the diffuse form showed the development of a marked bony decalcification on the roentgenograms; 3 of the 4 patients were elderly females.

Deep x-ray therapy does not appear to prolong life but has a definite place in the relief of pain and may prevent paraplegia when given to affected vertebrae. One case of solitary myeloma with survival for seven years is recorded.

Two roentgenograms. JOHN F. RIESSER, M.D.
Springfield, Ohio

Roentgenographic Examination of the Lumbosacral Spine in Routine Pre-Employment Examinations. Carl F. Runge. J. Bone & Joint Surg. **36-A**: 75–84, January 1954.

For many years it has been a universal experience in industrial and compensation practice that one of the most costly disabilities is low-back strain and its variations and sequelae. A program of routine pre-employment roentgen examination of the lumbosacral area aids in the rejection or placement of applicants and furnishes a useful record in the event of future claims of industrial injury.

This report from the Medical Department of the American Locomotive Company deals with 4,657 pre-employment roentgenographic examinations of the lumbosacral spine. The routine followed consisted in the making of anteroposterior and lateral roentgenograms on 14 × 17-inch film and a coned lateral roentgenogram of the lumbosacral joint on 10 × 12-inch film.

Defects which were felt to be of actual or potential clinical significance were found in 1,174 applicants, or 25.44 per cent of those examined. The following defects were considered grounds for rejection: (1) acquired defects, such as fractures, disk abnormalities, Pantopaque in the neural canal, and previous spine fusions; (2) hypertrophic changes of any degree; (3) all defects involving the lumbosacral joint, including transitional vertebrae and spondylolisthesis; (4) abnormal curvatures of marked degree; (5) miscellaneous defects such as tumors. Asymmetry of the lower lumbar and lumbosacral facets was not considered to bear any relation to low-back instability.

An extensive breakdown of the types of abnormalities and their incidence in the various age groups is presented.

Four roentgenograms; 10 tables.

THEODORE E. KEATS, M.D.
University of California, S. F.

Aspiration Biopsy of the Spine. Charles J. Frankel. J. Bone & Joint Surg. **36-A**: 69–74, January 1954.

Aspiration biopsy is a useful procedure in the diagnosis of obscure lesions of the vertebral column. The author used the method on 3 patients and was able to complete a diagnosis in 2 of them. The lesions were all in the thoracic, lumbar, and sacral portions of the spine. The descending aorta and accompanying veins and the thoracic duct are close to the upper five thoracic vertebrae, and therefore aspiration above the ninth thoracic vertebra carries with it some risk of damage to important structures.

All aspiration biopsies are done with roentgenographic control, under anesthesia. The patient is placed in the prone position, and a long 1.0-mm. stylet is inserted at an angle of 35 degrees toward the mid-line from a spot 6.5 cm. distant at the level desired. When the stylet is felt to strike bone, it is imbedded slightly by turning, and anteroposterior and lateral roentgenograms are made. If the placement is favorable, a second larger bone needle with a saw-tooth edge is passed over the stylet and the latter is withdrawn. Aspiration is carried out with a 50 c.c. syringe. After the needle is withdrawn, a core of bony material may usually be released by forcing the stylet through the needle.

The author has collected 37 cases in which aspiration biopsy was done. A definite diagnosis was established

in 20 cases. Of the 3 cases reported here, 2 were diagnosed as tuberculous spondylitis by aspiration biopsy. In the third case aspiration was unsuccessful but a repeat procedure one year later led to a diagnosis of angioendothelioma, even though the amount of tissue obtained was small.

Since only small bits of tissue are obtained by this method, a negative diagnosis in many cases simply indicates failure to aspirate pathological tissue and does not necessarily imply absence of disease.

Three roentgenograms; 2 photomicrographs: 2 drawings.

THEODORE E. KEATS, M.D.
University of California, S. F.

Spondylolisthesis. Analysis of Two Hundred One Cases. Paul C. Colonna. J.A.M.A. **154:** 398–402, Jan. 30, 1954.

Two hundred and one cases of spondylolisthesis and spondylolysis are reviewed, representing 1.25 per cent of all patients treated in the orthopedic clinic of the University of Pennsylvania in a ten-year period. The author favors the belief that the condition is initiated by trauma at birth, but that the activating element can often be trauma in adult life. Disability depends partly on the vertebral body displacement, although local arthritic changes and increase in the lumbosacral angle are contributing factors.

In patients suspected of having spondylolysis or spondylolisthesis, anteroposterior, lateral, and oblique roentgenograms should be obtained routinely. The diagnosis of spondylolysis can rarely be made without oblique views, while the lateral view of the suspected area is necessary to determine the degree of displacement of the vertebral body. While the defect in the neural arch usually occurs at the fourth or fifth lumbar vertebra, a unilateral or bilateral neural arch defect, with or without displacement, may be found at other levels. Arthritic changes are manifested by spurring and narrowing of the joint space. These changes are noted particularly on the posterior portion of the body near the intervertebral foramen.

Conservative treatment can relieve the great majority of cases and should be given a trial in all patients except those with severe spondylolisthesis. Surgical fusion was the treatment of choice in 29 cases of the author's series, with excellent results in 20.

Three roentgenograms; 3 tables.

THEODORE E. KEATS, M.D.
University of California, S. F.

Myelographic Sign of Brachial Plexus Avulsion. James C. White and Joseph Hanelin. J. Bone & Joint Surg. **36-A:** 113–118, January 1954.

The authors describe myelographic visualization of a traumatic meningocele as a sign of avulsion of roots of the brachial plexus in 3 cases. When such an injury occurs, a cuff of dura-arachnoid is torn out of the spinal theca. With retraction and shrinkage of the severed stump, a cavity is created which fills with spinal fluid. It is gradually enclosed by reformation of the ruptured arachnoid and dura, and a traumatic meningocele is formed. This can be readily filled with a radiopaque medium, and the presence of root avulsion is thus established.

When the plexus roots are actually torn out of the spinal cord, no form of treatment can help, but if there is a stretch or tear in the cords of the plexus more laterally, proper immobilization or even neurosurgical intervention may be of value. Clear-cut roentgenographic evidence of avulsion is therefore desirable.

Six roentgenograms; 1 drawing.

THEODORE E. KEATS, M.D.
University of California, S. F.

A Simple Technique for X-ray Measurement of Limb-Length Discrepancies. H. Melvin Kunkle and Earnest B. Carpenter. J. Bone & Joint Surg. **36-A:** 152–154, January 1954.

The equalization of limb lengths by epiphyseal arrest requires accurate measurement of the true differences in length and determination of the segments where discrepancy exists. A simple technic of x-ray measurement, similar to that used by White (South. M. J. **33:** 946, 1940), is described by the authors.

The patient lies on the x-ray table, the head of which is elevated slightly, with both of his feet exerting equal pressure on the foot rest. In cases of excessive discrepancy, the short limb is built up with plywood boards. A 14 × 17-inch cassette is shielded by lead-filled rubber in three sections, allowing separate exposure of the ankles, the knees, and the hips. These exposures are obtained by moving the Bucky tray while the patient remains motionless.

A metal ruler can be reproduced on the film for direct measurement. This is accomplished by drawing horizontal lines perpendicular to the film margin through identical points of each joint. The vertical distance between each line pair represents the discrepancy. This method has the advantage of enabling the height of the feet to be accurately measured, and also allows use of identical points in the pelvis in total length measurement when the hip joint is destroyed.

One photograph; 2 drawings.

C. M. GREENWALD, M.D.
Cleveland Clinic

Legg-Perthes Disease in Twins. Nicholas Giannestras. J. Bone & Joint Surg. **36-A:** 149–152, January 1954.

The author reports what are considered to be the first cases of Legg-Perthes disease in otherwise normal identical twins. Associated abnormalities or stigmata of diffuse epiphysitis were present in all previously reported cases in twins. The onset of symptoms in the two nine-year-old boys occurred within four months. The right hip was involved in one, and the left hip in the other. Of further interest was the concomitant presence of the disease in a younger sister. A roentgenographic study of the parents and 5 other siblings showed no involvement of any of the epiphyses, nor was there any familial history of coxa plana.

Six roentgenograms. C. M. GREENWALD, M.D.
Cleveland Clinic

Roentgenographic Visualization of the Patella. Arnold Sonnenschein. J. Bone. & Joint Surg. **36-A:** 109–112, January 1954.

The usual projection in the postero-anterior plane does not afford sharp focusing of the patella through the adjacent femur. This is true also of oblique projections where the exact angle of internal rotation and the angle of incidence of the x-ray must be known if maximal projection of this structure is to be obtained.

When it is important to determine exactly any changes in the form and structure of the patella without

overlay, the author recommends a technic which permits a broad, isolated presentation of the bone. This technic depends on the fact that, with complete relaxation of the quadriceps, the patella can be displaced from its intercondylar position, either medially or laterally, to almost half its width. To visualize more of the patella, the x-ray tube is placed on the subluxated side at a distance of 70 cm. and at an angle of 70 degrees to the bone. The extremity is rotated 10 degrees laterally if there is lateral dislocation and 10 degrees medially if dislocation is medial. The patient lies in a prone position and the limb is fixed by sandbags. A cassette is placed beneath the knee and the patella is forced outward or inward as much as possible. A wooden spatula is used to hold it in this position.

The patella is seen in a somewhat oblique posteroanterior projection and therefore appears slightly broader than in a pure anteroposterior view. In most cases one-third or one-fourth of the patella is covered by a femoral condyle. In spite of distortion, this view permits clear visualization of a large part of the patella without femoral overlay.

Seven roentgenograms; 1 photograph.

THEODORE E. KEATS, M.D.
University of California, S. F.

Physiological Bowing of the Legs in Young Children. John F. Holt, Howard B. Latourette, and Ernest H. Watson. J.A.M.A. **154:** 390–394, Jan. 30, 1954.

Exaggerated bowing of the lower extremities occurs with some frequency in apparently healthy, well nourished infants and children. The deformity is generally not due to rickets, osteochondritis, or serious developmental fault. The authors feel that it is the result of delayed resolution of the normal, physiological bowing that is present to some degree in all infants. In most instances the prognosis for complete, spontaneous regression of the bowing is excellent, the legs usually having straightened by the age of four to five years. Roentgenologic examination is imperative to rule out significant metabolic disease, but the results of such examinations may be misleading to those who are not aware of the true significance of these findings. Costly, time-consuming therapeutic measures may be instituted to the actual detriment of the patient.

Particular attention is directed to the confusing mechanical structural changes and exaggerated anatomic variants that are the result and not the cause of the bowing. These include thickening of the inner diaphyseal cortex of the femurs and tibias, triangular distal femoral and proximal tibial epiphyses with fragmented appearance of metaphyses of the femurs and tibias at the knees, overgrowth of bone in one or both medial femoral metaphyses, and a varying degree of internal angulation of the distal tibial metaphysis along with minimal wedging of the adjacent epiphysis.

Five illustrative cases demonstrating spontaneous correction of physiological bowing are presented.

Nine roentgenograms.

THEODORE E. KEATS, M.D.
University of California, S. F.

Profiles of the Carpal Canal. James N. Wilson. J. Bone & Joint Surg. **36-A:** 127–132, January 1954.

On routine views, injuries and abnormalities of the carpal bones, particularly those related to the anterior surface of the carpus, can be easily overlooked. The four most superficial bony prominences of the palmar surface, and thus the most vulnerable to direct trauma, are the navicular tubercle and the ridge of the greater multangular radially, and the pisiform and the unciform process of the hamate on the ulnar border. The transverse carpal ligament spans these prominences, roofing the carpal canal. Within this canal run the flexor tendons and median nerve.

The radiographic outline of these four bony pillars and their relation to the carpal canal can be clearly seen with an axial projection of the base of the palm. The volar surface is placed against a cassette, and the wrist is dorsiflexed 60°, with the central ray directed along the longitudinal axis of the third metacarpal.

The author presents several case reports that demonstrate encroachment on the canal both following trauma and as the result of developmental disturbances including a bipartite capitate. Calcification of the bursa between flexor carpi ulnaris and pisiform is well visualized on profile views, as are certain supernumerary carpal bones not seen on routine projections.

Nine roentgenograms; 3 photographs.

C. M. GREENWALD, M.D.
Cleveland Clinic

Gout in a Negro Woman. Report of a Case. Harry Bartfeld. J.A.M.A. **154:** 335–336, Jan. 23, 1954.

A case of gouty arthritis in a sixty-year-old Negro woman is reported. All the criteria for gout were fulfilled, including the clinical signs, hyperuricemia, and uric acid tophi. Roentgenograms of the hands, feet, and ankles revealed generalized osteoporosis. Crescentic, irregular destructive erosions were found between the first cuneiform and first metatarsal bones. There were destructive areas in the heads of the first metatarsal and other metatarsals. Some productive changes were also visible.

Only about 2 per cent of all cases of gout occur in women. It is rare in the Negro race.

One roentgenogram.

DONALD DEF. BAUER, M.D.
Coos Bay, Ore.

Osteochondroma of the Astragalus. Robert Austin Milch. Am. J. Surg. **87:** 145–148, January 1954.

Although osteochondromata are unquestionably the most common of all skeletal tumors, their occurrence in the astragalus is unusual. The author's patient was a thirteen-year-old white schoolboy who noticed a painless swelling of the outer aspect of his left ankle approximately two years before admission. It had progressively enlarged and was associated with inversion of the foot, before the patient noticed some pain on weight-bearing. Radiographic examination demonstrated an elliptical mass arising from the outer portion of the left astragalus and impinging upon the posterior aspect of the lateral malleolus. The tumor was excised and the pathological report was "benign osteochondroma." Recovery was uneventful. Re-examination five years after excision demonstrated a slight varus of the heel and minor limitation of subastragalar motion. Roentgenograms showed slight deformity of the left lateral malleolus and an abnormal convexity of the lateral wall of the astragalus. The patient experienced no pain or inconvenience. A brief general discussion of osteochondromas concludes the report.

Two roentgenograms; 1 photograph.

ALLIE WOOLFOLK, M.D.
Pittsburgh, Penna.

Osseous Changes in Myopathy. J. N. Walton and C. K. Warrick. Brit. J. Radiol. **27:** 1–15, January 1954.

Thirty-eight patients with progressive muscular dystrophy were studied roentgenographically. Films showed thinning of the shafts and rarefaction of the ends of long bones, impaired development of flat bones, scoliosis, coxa valga, decalcification eventually involving the entire skeleton, and progressive deformity and disorganization of the bones of the feet. The severity depended upon the duration of the disease. The changes were considered to be due to disuse rather than an essential part of the disease.

Seventeen cases of dystrophia myotonica were studied. In these the changes were confined to the skull. The sella was smaller than normal and the vault thicker than normal. The changes were progressive and are regarded as essential to the disease.

Six cases of myotonia congenita showed no consistent changes from the normal.

SYDNEY J. HAWLEY, M.D.
Seattle, Wash.

GYNECOLOGY AND OBSTETRICS

A Clinical Analysis of the "Angiograms" Found in the Course of Hysterosalpingography with Special Reference to Tuberculosis of the Female Genitals. Kanji Kika. Am. J. Obst. & Gynec. **67:** 56–63, January 1954.

In the course of hysterosalpingography as carried out in 1,203 cases (1,200 of sterility; 3 post-menopausal), lymphatic or venous penetration of iodized oil occurred in 55 instances. Four to 8 c.c. of iodized oil was injected at pressures of less than 100 mm. Hg, and films were taken at five minutes and twenty-four hours routinely. Excessive pressure, too much iodized oil, variations in the phase of the menstrual cycle, and ligation of the tubes appeared to play no role in the passage of the medium into the vessels. The 55 cases in which "angiograms" were thus produced were of 5 varieties: 30 with normal uterine contour and blocked tubes; 15 with atrophic or irregular contour and blocked tubes; 6 with normal uterine contour and patent tubes; 2 cases of lymphatic penetration with atrophic or irregular uterine contour and blocked tubes; 2 cases with uterus bicornis and blocked tubes.

Forty-five of the 55 cases reported were further studied by culture, biopsy, or both for tuberculosis, and this diagnosis was confirmed in 32 cases. In 7 cases a presumptive diagnosis of tuberculosis was made because of infertility, history of tuberculosis, menstrual disturbance, or characteristic pelvic findings. In 6 cases no evidence of tuberculosis was found.

The author concludes that the most prominent causative factor in the production of uterine angiograms is uterine damage due to inflammatory change, especially tuberculous disease of the endometrium and myometrium, which results usually in menstrual disturbance.

Seven roentgenograms; 1 photomicrograph; 1 table.
WARREN A. NAFIS, M.D.
Jefferson Medical College

On the Incidence of Calcified Uterine Fibroids. Alex L. Finkle, Charles L. Prince, and Peter L. Scardino. Am. J. Obst. & Gynec. **67:** 79–84, January 1954.

Only 5 calcified fibromyomas of the uterus were found in 4,000 roentgen studies of female genitourinary tracts made over a six-year period. Only 1 of the 5 patients was under fifty years of age. In 4 women bladder symptoms were prominent. All had varying degrees of lower abdominal discomfort. Hysterectomy fully relieved the 2 youngest patients. Anodynes and/or antibiotic therapy produced adequate relief in 2 others. No treatment was necessary in the fifth case. Calcification within fibromyomata of the uterus is apparently an innocuous condition but can produce dramatic pressure effects on nearby structures.

Five roentgenograms. WARREN A. NAFIS, M.D.
Jefferson Medical College

Migration of Foreign Body Following Criminal Abortion. James W. Hall. Am. J. Obst. & Gynec. **67:** 179–180, January 1954.

A case is reported where a No. 16 French rubber catheter migrated from the cervix through the uterus and tube without perforation of either following criminal abortion in a 35-year-old white woman. Symptoms persisted with negative physical findings for over a year. It is stressed that roentgenograms could have provided an earlier diagnosis.

One photograph. WARREN A. NAFIS, M.D.
Jefferson Medical College

Gas Within the Foetus Indicating Foetal Death. A. F. Crick and F. H. Sims. J. Fac. Radiologists **5:** 126–133, October 1953.

The authors review a series of 7 cases of fetal death in which the diagnosis was made by the finding of gas within the fetus, primarily in the heart and abdominal vessels. The pattern of the gas shadows is quite characteristic and is considered pathognomonic of fetal death regardless of the presence or absence of other signs. Overlying gas in the maternal bowel must of course be excluded, but this is apparently not too difficult provided the proper lateral exposure is made, including the entire fetus. An anteroposterior projection is not of much value in this respect. The authors consider the demonstration of gas in the vascular system a much earlier radiologic indication of fetal death than the finding of overlap of the skull bones.

By means of special bacteriologic and chemical analyis of the gas found in the reported cases, it is proved quite conclusively that this is not caused by bacterial action and consists almost entirely of nitrogen. The authors are unable to shed any light upon the mechanism of its formation.

Four roentgenograms show to excellent advantage the appearance of the described gas shadows in the fetus.

MAURICE TATELMAN, M.D.
Detroit, Mich.

A General Formula for Pelvicephalometry. Natal C. Carabello. Am. J. Roentgenol. **71:** 121–130, January 1954.

The author has devised a general formula for pelvicephalometry provided the two extreme points of the part to be measured can be visualized. The formula for this factor is simple and constant for all types of problems.

Eight roentgenograms; 3 diagrams; 1 table.
M. HARLAN JOHNSTON, M.D.
Jacksonville, Fla.

Simplified Roentgen Cephalometry. Julius Lieberman, Gerald Segal, and Paul S. Andreson. Am. J. Obst. & Gynec. **67**: 76–78, January 1954.

The authors, using Isaacs' method of roentgen pelvimetry (Am. J. Roentgenol. **63**: 609, 1950. Abst. in Radiology **56**: 623, 1951) reviewed cephalometric measurements of 500 cases. Radiographic distortion was correlated with actual clinical measurements at birth. It was concluded that actual fetal head diameters may be accurately obtained by subtracting 1.5 cm. from the occipitofrontal measurements and 1.8 cm. from the biparietal measurements found roentgenographically.

Two roentgenograms. WARREN A. NAFIS, M.D.
Jefferson Medical College

A Simplified Method of Correcting Roentgenographic Measurements of the Maternal Pelvis and the Fetal Skull Gerhart S. Schwarz. Am. J. Roentgenol. **71**: 115–120, January 1954.

The method of correcting for roentgen ray beam divergence when measuring the diameters of the maternal pelvis and the size of the fetal skull are classified into four groups: (1) geometric, in which calculations are made according to the target-film and object-film distances, (2) metal centimeter markers, (3) precision stereoscopy, and (4) the parallax method.

The author describes a simple mental calculation which yields from the known object-film distance a correction factor for any structure lying parallel to the film when the target-film distance is 39–40 inches or 100 cm. The factor is obtained by subtracting the object-film distance in centimeters from the target-film distance of 100 cm. A simple slide rule has been constructed which calculates the correction factor and corrects the measured diameter in a single operation. A more elaborate slide rule is described which can be used for a variety of target-film distances and yields volume capacity of pelvic diameters, volume of fetal head and the corresponding fetal age, without any additional effort of manipulation.

Two drawings. M. HARLAN JOHNSTON, M.D.
Jacksonville, Fla.

THE GENITOURINARY SYSTEM

Translumbar Aortography. Ian F. Potts. M. J. Australia **1**: 173–177, Jan. 30 1954.

For translumbar aortography, a 6- to 6.5-inch 18-gauge needle, short-beveled, fitted with a stylet and a Luer-Lok butt, a 20 c.c. Labat syringe with finger loops, and a 10-inch length of plastic tubing are the required instruments. The patient is prepared by a cathartic the night before and a saline enema the morning of the examination. Anesthesia may be local or general.

With the patient prone on the radiographic table, the needle, with stylet in place, is inserted four fingers' breadth from the mid-line under the lower border of the left twelfth rib. It is then advanced along the body of the first lumbar vertebra to enter the aorta at the level of the twelfth thoracic vertebra after removal of the stylet. The injection is made as fast as possible, two to two and a half seconds. The first film is taken as the last 4 c.c. are being injected. The needle is withdrawn and a second exposure is made as quickly as possible. In the author's earlier cases 70 per cent Diodrast was used, and in the later cases 70 per cent Diodone.

The physiological effect of the injection is a brief hypotension associated with bradycardia, followed by hypertension with increased pulse pressure and tachycardia for several minutes. The only 3 reported deaths occurred when 80 per cent sodium iodide was used and when the bulk of the injection was made into the superior mesenteric artery.

This paper deals particularly with the application of translumbar aortography to urologic diagnosis. The procedure is of aid in the differential diagnosis of simple renal cyst from tumor. Cysts are avascular and hence show no blood supply on the arteriogram, nor do they increase in density as does the rest of the kidney in the nephrogram. Cysts communicating with the collecting system will increase in density on a subsequent pyelogram. On the contrary, tumors are vascular and therefore produce puddling; the normal regular arterial pattern is disturbed, and the arteries are irregular and commonly tortuous; slow circulation with retention of the contrast medium may be demonstrated.

With satisfactory technic the aortogram is useful in preoperative evaluation of aberrant vessels. In absence of function, when the ureter cannot be catheterized, the aortogram and nephrogram will show whether a kidney is present and reveal the adequacy of its blood supply. The presence of congenital abnormalities, which can usually be shown by pyelography, may be confirmed.

Adrenal tumors are best shown on the nephrogram, which shows, also whether or not an adjacent tumor arises from the kidney. Hemangioma, which is a frequent cause of hematuria, should be demonstrable if it is of sufficient size. Renal artery thrombosis produces a complete block and absence of shadow in the nephrogram. Infarcts appear as avascular wedge-shaped areas with the apex directed medially.

Six roentgenograms. SHOZO IBA, M.D.
Huntington Park, Calif.

The Value of the Perirenal Insufflation of Air as a Diagnostic Method of Estimating Gross Anatomical Enlargement of the Suprarenals and Kidneys. Z. Z. Godlowski. J. Fac. Radiologists **5**: 148–154, October 1953.

The author discusses the clinical indications and technic of direct perirenal insufflation of air for the study of the suprarenals and kidneys, briefly reviewing the literature. His own experience includes investigation of 6 cases with a total of 14 separate insufflations. One of these cases is illustrated by radiographs and a photograph of the pathologic specimen.

The author feels that the danger of air embolism in perirenal insufflation has been greatly exaggerated and that most complications previously attributed to that cause were probably due to severe distention of Garota's fascia by the injected air, producing a vasovagal syncope on the basis of a vascular stretch-reflex. His technic calls for insufflation of only one side at a time, injection of only 300 c.c. (rarely up to 400 c.c.) of air at the rate of 10 c.c. per minute with a pneumothorax apparatus and, of particular importance, injection of 20 c.c. of a local anesthetic into the perirenal space prior to the introduction of air to anesthetize completely the nerves which would mediate the stretch-reflex. Limiting the amount of air and unilateral insufflation also minimize the danger of mediastinal emphysema.

The author does not compare this method with the presacral retroperitoneal insufflation of air, which is

certainly now in much greater favor, although he does mention the latter briefly.

MAURICE TATELMAN, M.D.
Detroit, Mich.

Presacral Pneumography. Edwin A. Seidman, Abdol H. Islami, and Renato R. Espinosa. J. M. Soc. New Jersey **51**: 25–30, January 1954.

A technic of presacral pneumography used in 50 patients is reported. Following routine preparation of the patient, an ordinary lumbar puncture needle is directed into the presacral space, and oxygen, 15 c.c. per kilo of body weight, is injected through the needle. With the patient on his back, the head is elevated about 15 degrees to facilitate diffusion of the oxygen into the renal areas. Roentgenograms are obtained in anteroposterior, oblique, and lateral projections. Various opacifying procedures for the urinary tract or the renal circulation may be carried out in conjunction with presacral pneumography. No systemic reactions have been encountered with this technic, although mild transient side-effects from diffusion of the gas into the mediastinum or cervical tissues have been noted.

The procedure is a valuable aid in diagnosis of renal tumors, adrenal tumors, and perinephritic lesions. While no radiographic criteria establish the diagnosis of perinephritic abscess, presacral pneumography demonstrates perinephritic involvement, by interference with diffusion of gas around the affected kidney and obliteration of the psoas muscle margin. Previous inflammatory intra-abdominal disease limits the diffusion of gas and interferes with the value of presacral pneumography.

Four case reports are included, with 5 roentgenograms.

RICHARD F. MCCLURE, M.D.
Redondo Beach, Calif.

Cystourethrography in the Male. Basil M. de Lambert and Norman F. Greenslade. M. J. Australia **1**: 159–162, Jan. 30, 1954.

The authors describe the technic of cystourethrography developed by Edling of Stockholm (Acta radiol., Suppl. 58, 1945). They use 7.5 per cent sodium iodide solution or 12 per cent Diodone solution or Iodoxyl in sterile water. Up to 200 c.c. are employed for the examination. A special apparatus is required to obtain a water-tight junction at the penile meatus.

A preliminary film is obtained after the patient has emptied the bladder. Films are then taken, during injection, in the anteroposterior and in each 45-degree oblique projection. The anteroposterior film is taken with 15-degree caudal tube tilt and one of the oblique films is taken with a 10-degree cephalad tube tilt. A micturition film is taken in the appropriate position after review of the previous films.

The examination should be deferred for ten to fourteen days after dilatation of a stricture. It is contraindicated in acute infections of the urethra and bladder.

The procedure has been used by the authors in about 100 cases in two years. They briefly describe 6 cases, including anterior urethral stricture, prostatic enlargement, adenomatous regrowth in a punch cavity in the urethra, atonic bladder, and an undiagnosed case with cystic swelling in the ischiorectal fossa probably associated with a malignant growth.

Twelve roentgenograms. SHOZO IBA, M.D.
Huntington Park, Calif.

Renal Displacement and Pyelographic Deformity Produced by Amebic Infection of the Liver. David Givner. J. Urol. **71**: 32–34, January 1954.

A 32-year-old man was admitted to the Veterans Administration Hospital, Fort Benjamin Harrison, Indianapolis, because of weight loss, intermittent right abdominal pain, and weakness. He had had attacks of diarrhea while stationed in the Philippines in World War II, but a diagnosis of amebiasis had never been made. By roentgenographic study he was found to have elevation and some restriction of the right hemidiaphragm, obliteration of the right psoas outline, and depression, rotation, and some displacement of the right kidney toward the mid-line. The gallbladder was not visualized, and the gastrointestinal tract was normal. Stool examinations were negative for parasites including amebae. There was progressive enlargement of the liver.

The patient was believed to have an hepatic abscess and a right perinephric abscess. Treatment with emetine and Diodoquin was followed by rapid subsidence of symptoms. Studies during convalescence showed a return of the right kidney to normal position, and a normal right pyelogram.

The author believes that amebic infection of the liver should be considered in the differential diagnosis of displacement and pyelographic deformities of the right kidney.

Two roentgenograms. ARTHUR S. TUCKER, M.D.
Cleveland Clinic

Fate of Hydronephrotic Kidney (Aortographic and Retroperitoneal Pneumographic Findings). Gregory S. Slater and Joseph Mandell. J. Urol. **71**: 14–16, January 1954.

A case is reported to demonstrate the effect of hydronephrosis on the blood supply of the involved kidney.

A 30-year-old colored woman was examined at the Veterans Administration Hospital, San Francisco, because of intermittent, knife-like, non-radiating, right lumbar pain accompanied by chills and fever. A urogram showed a non-functioning right kidney. On cystoscopy the right ureter was found to be obstructed. Translumbar aortography showed no vascular supply to the right kidney, and very poor delineation of this kidney was obtained by retroperitoneal air insufflation. All studies showed a normal left kidney.

At operation a large multicystic hydronephrotic right kidney and right hydro-ureter were removed. The authors conclude that the blood supply to a hydronephrotic kidney which is no longer functioning is markedly diminished.

Three roentgenograms; 1 photograph.

ARTHUR S. TUCKER, M.D.
Cleveland Clinic

Nephrocalcinosis: A Review. JD Mortensen and Archie H. Baggenstoss. Am. J. Clin. Path. **24**: 45–63, January 1954.

This article consists of a review of the clinical and pathological aspects of nephrocalcinosis. It supplements one in RADIOLOGY on the roentgen features of this condition (Mortensen *et al.*: Roentgenographic Demonstration of Histologically Identifiable Renal Calcification. Radiology **62**: 703, 1954).

Three photomicrographs; 2 photographs.

HYDATID DISEASE

Hydatid Disease. Part II. Hydatid Disease in the Renal Tract, Bone, Muscles, and Nervous System. W. J. Latham. J. Fac. Radiologists **5**: 83–95, October 1953.

The author reviews the radiologic manifestations of hydatid disease in the genitourinary tract, osseous system, muscles, and central nervous system. Renal cysts as a rule produce enlargement of the kidney shadow but displacement of the kidney is unusual. Changes in the calyceal and pelvic structures on pyelography are usually those incident to pressure effects, but in some cases where the cyst has ruptured and communicates partially or completely with the calyceal system, opaque material enters the hydatid cyst and produces a characteristic picture—the so-called "wine-glass" shadow or some of its variations. With complete emptying of the cyst and possible partial calcification, differentiation from renal carbuncle and a tuberculous cavity in the kidney may be difficult.

Four stages of hydatid bone disease are recognized. In the first stage the lesions are purely destructive, producing round cyst-like spaces which have been likened to a bunch of grapes. The second stage, rarely seen, is that of infection, and the roentgen findings are those of an osteitic reaction. Later stages are more characteristic, showing the so-called "ossifluent abscess" and eventually replacement of the bone by a mass of calcareous bubbles. Involvement of the spinal column is considered fairly characteristic, with a paraspinal soft-tissue mass, small round cyst-like areas of destruction in the anterior portion of the vertebral bodies, and no evidence of narrowing of the adjacent intervertebral disk space.

In hydatid disease of the muscles and other soft tissues, radiology plays but a small part. The chief point of importance is that the cyst shadow is of greater density than that of lipoma, which is frequently suggested by the clinical findings.

Hydatid cysts of the central nervous system are apparently quite rare. Lesions in the brain produce findings similar to other intracranial masses. Calcification occurs frequently, mainly in a linear fashion. Angiography indicates a complete lack of vascularity of the mass. Intraspinal hydatids usually block the flow of opaque material on myelography, but the nature of the lesion is not apparent.

Thirty-three illustrations, including 23 roentgenograms.

MAURICE TATELMAN, M.D.
Detroit, Mich.

TECHNIC

Fast Cameras for All-Purpose Photofluorography. Paul C. Hodges. Am. J. Roentgenol. **71**: 102–109, January 1954.

The development of fast cameras for all-purpose photofluorography is traced, with particular attention to the difficulties, technical and otherwise, in the development of a 70-mm. camera. That described by the author uses a reflector optical system (designed by Henyey and Greenstein) employing a doublet of spherically ground crown and flint glass. A 24 inch concave-surfaced mirror and a concave fluoroscopic screen are utilized.

It has a resolving power of 20 lines per millimeter and the speed is more than six times that of the F/1.5 Ektar. The film-moving mechanism allows exposure of six frames per second.

The development of fast cameras of this type should find wide clinical application in cerebral angiography and angiocardiography, as well as photofluorography of the abdomen and extremities.

Six photographs; 1 diagram.

M. HARLAN JOHNSTON, M.D.
Jacksonville, Fla.

An Automatic Regulator for Providing Constant Brightness of the Fluoroscopic Screen. Russell H. Morgan and Ralph E. Sturm. Am. J. Roentgenol. **71**: 110–114, January 1954.

For maintaining the brightness of the fluoroscopic screen at a relatively constant level regardless of the anatomic structure being studied, the authors have devised a "fluororegulator." The nucleus of the apparatus is similar to a photo-electric timer, namely a radiation detector which utilizes a multiplier phototube. In addition there is a saturable reactor which is connected in series with the filament transformer. Current generated by the roentgen detector therefore has control over the roentgen tube current, and therefore the output. As the fluoroscopic screen brightens, the impedance in the saturable reactor increases, which decreases the current in the roentgen tube filament circuit, thus regulating screen brightness. As the screen becomes less bright, impedance is reduced, with resulting increased current in the filament circuit.

In actual practice, the changes in roentgen tube output compensate for changes in anatomical part thickness.

The maintenance of constant level of brightness of the fluoroscopic screen necessitates a wide range of milliamperage, in passing from fluoroscopy of the chest to fluoroscopy of the abdomen.

The fluororegulator was designed for the Johns Hopkins image amplifier but should be valuable in ordinary fluoroscopic procedures.

Two diagrams; 2 graphs.

M. HARLAN JOHNSTON, M.D.
Jacksonville, Fla.

Direct X-Ray Enlargement and Normal Views. Comparative Studies for Clinical Limitations (Part I). H. Büchner. Fortschr. a. d. Geb. d. Röntgenstrahlen **80**: 71–87, January 1954. (In German)

Recently various opinions have been expressed regarding the value of direct roentgen magnification. Though it is generally believed that this method offers no advantage in the observation of fine bone detail, there remains some disagreement as to the usefulness of the procedure. In an attempt to throw light on the problem, the author has made comparative studies of optical magnification, direct x-ray magnification, and the normal roentgenogram.

A 0.3-mm. focal spot tube was used. Tests were made with wire mesh, wires of various caliber, sand particles, bone, and the Franke test pattern, at various distances from the x-ray film. Non-screen films were used for most of the experiments. The factors of sharpness depend on the object, type of screens and films, focal spot of the tube, projection distance, and geometrical relationship of film, object, and focal spot.

It was determined that optical magnification gave no greater detail than the original conventional picture

and that direct enlargement caused loss of detail. Thus, a fine fracture at the lower end of the radius was very sharply defined on the normal film but less clearly visualized on the enlarged picture. A fracture of the navicular was positively identified on the normal film but appeared questionable on the enlargement. The author concludes that, with a fine focus and direct enlargement up to 2 to 1, there are blurring and distortion of detail especially in thick objects, as compared with the normal. Optical magnification of 1.2 to 1.5 gives equal visualization of the fine details, and even above this degree of magnification the image is not inferior to that observed on the direct enlargement. Non-screen film offers no diagnostic advantage.

Eleven figures. E. W. SPACKMAN, M.D.
Fort Worth, Texas

Roentgen Recognition of Small Bone Defects by Direct X-ray Magnification and Tomographic Magnification with the Fine-Focus Tube. K. Werner and W. Bader. Fortschr. a. d. Geb. d. Röntgenstrahlen **80:** 87–90, January 1954. (In German)

Bone defects, even when comparatively large, may be overlooked on the conventional x-ray films, especially if located in the spongiosa. Tomography will frequently assist in demonstrating small defects. The authors used a 0.3-mm. focal spot tube, which approaches very closely a point source and should be used regularly with direct x-ray image enlargement. When the object-focus and object-film distance are equal, the enlargement is 2:1.

Advantages of direct magnification are stated by the authors as follows: (1) reduction of the half-shadow (penumbra effect); (2) demonstration of the bone structure of the second order (0.5 mm.); (3) separation of details which are superimposed in the usual conventional views.

To simulate conditions in the living subject, fresh bone specimens from the head of the tibia were used. Five holes were drilled in the spongiosa, ranging from 2 to 10 mm. in diameter and 10 mm. in depth. Comparison was made between the conventional films, fine-focus tube with the usual technic, direct magnification, and tomographic magnification. Bone structure was observed to be much sharper in both detail and contrast with the fine-focus tube. Minute areas of destruction within the bone were observed to better advantage in the direct magnified image. Tomography using both longitudinal and lateral shifts gave sharper detail than conventional technic. The authors recommend this procedure in primary and metastatic bone tumors, bone tuberculosis, and certain types of fracture, especially of the vertebral bodies.

Four roentgenograms. E. W. SPACKMAN, M.D.
Fort Worth, Texas

RADIOTHERAPY

Treatment of Malignant Cutaneous Lesions. Earl D. Osborne. J.A.M.A. **154:** 1–4, Jan. 2, 1954.

In a general discussion of the various methods of treating malignant cutaneous lesions, the author reviews the advantages and disadvantages of scalpel surgery, electrodesiccation, chemosurgery, and radiation therapy. He favors curettage and electrothermic destruction over all methods in the treatment of the majority of malignant cutaneous lesions, for the following reasons: (1) curettage yields valuable information obtainable in no other way; (2) results are immediate; (3) plastic repair can be performed subsequently when necessary; (4) five- and ten-year results are excellent.

The use of x-ray therapy even in the most experienced hands has these disadvantages: (1) the patient must be accessible for two to four weeks; (2) at times the depth and extent of a lesion cannot be estimated by the most expert radiologist; (3) disastrous late sequelae occur in a definite percentage of patients. Even so, irradiation is unsurpassed in its results in radiosensitive, infiltrating lesions and where cosmetic results are of paramount importance. Scalpel surgery is indicated in Paget's disease of the nipple and in malignant melanoma when operations in continuity are desirable.

R. F. LEWIS, M.D.
Cleveland Clinic

Radium in Malignant Cutaneous Disease. C. F. Lehmann and J. L. Pipkin. J.A.M.A. **154:** 4–8, Jan. 2, 1954.

Two interstitial technics of radium-needle application are described: (1) a short-time high-intensity method and (2) a long-time low-intensity method. The first method, previously described (Arch. Dermat. & Syph. **63:** 312, 1951. Abst. in Radiology **58:** 316, 1952), employs 10 mg.-radium needles with an effective length of 12 mm. and a wall filtration of 0.3 mm. platinum. The treatment time is two and a half to three hours. The needles are placed 3 mm. apart; possible arrangements are briefly outlined.

The advantages of the intensive method are several: (1) It does not require hospitalization. (2) Since a single treatment is required, the patient is saved repeated trips to the office. (3) The short treatment time entails an economical use of radium. (4) The short length of the needles facilitates the treatment of lesions in certain locations where shielding is difficult or where intensive irradiation in a small area is desired.

The low-intensity technic employs radium needles of 0.66 mg. per cm. The effective length is 15 mm. and the filtration 0.5 mm. of platinum and iridium. The radiation from these is 100 per cent gamma. The needles are placed 1 cm. apart in various arrangements and are sutured into place with a fine wire. Since the authors do not treat with radium lesions more than 1 cm. thick, only single-plane insertions are used. The needles are left in place five to nine days, depending on the amount of radium used, for a dose of 4,000 to 6,000 gamma roentgens. The area treated includes a border around the palpable lesion one-fourth to one-third of its largest diameter. The area selected is infiltrated around the margin with 2 per cent procaine. This raises the lesion, facilitating the insertion of the needles in a plane parallel to the skin surface.

The selection of technics is discussed in detail. In general, the short, intensive technic is used for the smaller untreated lesions. Larger or previously treated lesions require the long, low-intensity technic. The absolute cure rate achieved with the proper selec-

tion of these technics in a series of 8,892 skin cancers was 85 per cent (this includes all treated and untreated lesions). The relative cure rate with the low-intensity method was 95 per cent, and with the high-intensity method was 97 per cent.

Four diagrams.

R. F. LEWIS, M.D.
Cleveland Clinic

Diagnosis and Treatment of Carcinoma of the Eyelids. Eugene F. Traub. J.A.M.A. **154:** 9–12, Jan. 2, 1954.

The various types of cutaneous cancer found on or about the eyelids are discussed and the diagnostic features outlined. The treatment employed in 28 of the 36 patients comprising this series was a combination of curettement, electrocoagulation, and irradiation. Curettement and electrocoagulation alone, irradiation alone, or treatment with a Sherwell cautery was used in the remainder of the patients.

The author prefers to irradiate the freshly curetted lesion with 100-kv. unfiltered x-rays, achieving a dosage of 1,500 to 2,500 r. Provided the growth is an early one that has not been previously treated or neglected, this method should accomplish better than 95 per cent cure with one treatment. Radium in equivalent dosage may be employed either interstitially or by surface application; however, when it is possible to completely remove the tumor, surface application generally suffices. Contact roentgen therapy may prove valuable but requires special equipment and technics.

The complications of irradiation are discussed, and the danger to the crystalline lens in particular is stressed. It is emphasized that surgery alone offers the least in the treatment of carcinoma of the eyelid.

Of the author's 36 cases, 5 were squamous-cell carcinomas. Thirty-one cases, including the squamous-cell lesions, were apparently cured in one treatment (2-year minimum follow-up). Of 10 previously treated lesions, 6 received one, 2 required two, and 2 were given three or more treatments.

One table.

R. F. LEWIS, M.D.
Cleveland Clinic

Cancer of Forehead and Scalp. J. B. Howell and J. Murray Riddell, Jr. J.A.M.A. **154:** 13–20, Jan. 2, 1954.

Carcinoma of the scalp may be either primary or metastatic. The natural course of the disease is discussed and the routes of spread are enumerated.

The authors consider carcinoma of the scalp a more dangerous and difficult-to-cure neoplasm than is generally realized. The need for individualization of therapy is emphasized. The age of the patient, the size, location, extent and rate of growth of the lesion, and previous treatment, if any, must all be taken into consideration.

In relation to treatment, carcinomas of the scalp are divided into four groups depending on their extent. Group I includes all lesions involving the scalp and subcutaneous tissues but not the periosteum. Group II includes all lesions extending into the periosteum but not into the bone. Lesions of Group III involve bone but not the meninges. Group IV lesions have penetrated to the meninges and/or brain.

The treatment of cancers of the forehead and scalp is primarily surgical, but radiation may be used for lesions of Group I if they are not too large. For this purpose interstitial low-intensity radium needles offer many advantages.

Two roentgenograms; 5 photographs.

R. F. LEWIS, M.D.
Cleveland Clinic

Roentgen Irradiation in the Treatment of Epithelioma. George C. Andrews, Anthony N. Domonkos, and Wilbur B. Hurlbut. J.A.M.A. **154:** 21–22, Jan. 2, 1954.

The authors briefly discuss the advantages and disadvantages of surgery and irradiation in the treatment of epithelioma. The technic of divided-dose x-ray therapy is considered in some detail as affected by the size and location of the tumor.

Of 1,000 cases of epithelioma of which records were taken at random from the authors' files, 410 were biopsy-proved and 220 of these were followed five years or more. Because of inadequate x-ray technic commonly employed at the time some of these 220 patients were treated, the five-year cure rate was only 93 per cent, as compared with 96 per cent in those treated by excision. Only 94 of 490 unbiopsied patients treated with the modern divided-dose technic were followed five years or longer. The cure rate in this group was 98.9 per cent.

Four photographs.

R. F. LEWIS, M.D.
Cleveland Clinic

On the Treatment of Cavernous Haemangioma with Special Reference to Spontaneous Regression. J. Walter. J. Fac. Radiologists **5:** 134–140, October 1953.

A series of 88 cases of cavernous hemangioma were treated either by 100-kv. unfiltered irradiation or, in a few cases, by a Philips' contact machine, and the results were compared with 83 cases of untreated cavernous hemangioma of various sites. No cases of port-wine stain, spider angioma, or lymphangioma were included.

The surface dose ranged from 300 to 500 r in all but 4 cases, averaging 380 r. The face received a smaller dose than the trunk. In half the patients a single treatment sufficed; in a third, 2 doses were necessary and in only 4 were four doses required. The average interval between doses when more than one treatment was given was 4.3 months.

In evaluating results, "satisfactory" was taken to mean satisfying both parents and radiotherapist, though not necessarily indicating complete disappearance of scarring or discoloration. On this basis, satisfactory results were obtained in 94 per cent of the treated cases at five years and in 96 per cent of the untreated cases. No significant difference between the two series was found to exist at yearly intervals, except for the first year, when a greater speed of resolution occurred in the treated group. In 52 cases treated earlier by a Philips' contact machine, with higher doses (average surface dose 800 r), the end-results at five years were similar, but resolution was more rapid. Forty-six cases treated still earlier, with contact irradiation in doses of 1,200 to 1,500 r, showed satisfactory regression but poor cosmetic results.

Analyzing results from the standpoint of radiosensitivity at various ages disclosed no significant difference in sensitivity during the first five years, as

judged by ultimate regression five years after treatment. Treatment of lesions present after five years of age gave only 72 per cent satisfactory end-results. In only 4 of 10 patients of five to fifty-eight years with angioms dating from early infancy were results satisfactory.

Possible causes of failure of treatment include: (a) some inherent factor, or "radio-insensitivity," (b) faulty radiation technic—dosage too high, too low, too frequent, or too infrequent; (c) previous treatment, especially CO_2 snow; (d) presence of ulceration and sepsis. Lesions located on the mucosal surface of the lip gave poorer results than others.

Regarding overall treatment policy, a "wait-and-see" attitude is regarded as safe and reasonable, since nature will produce a cosmetic result certainly equal to that attained by treatment in an equal percentage of cases. Radiation appears to speed the process of regression, a factor which may be of importance in lesions near the eye, lips, or perineum, where ulceration or the mass itself may interfere with function. Likewise, as many hemangiomata demonstrate early enlargement followed by regression, lesions on the face may merit treatment on the ground that it is impossible to tell in advance what size will actually be reached. The decision in the individual case will be influenced not alone by the size and location of the lesion, but also by the temperament of the parents and the practical and psychological importance of the time factor.

Dosage recommended is 600 to 800 r on the skin for the typical lesion, with lower levels on the face. The dose can be repeated in four to six months. Conservatism in repetition is indicated.

One graph; 2 tables.

DONALD OTTO, M.D.
Detroit, Mich.

Treatment of Cancer of the Tongue and Its Cervical Metastases with Irradiation. Charles L. Martin. South. M. J. **47:** 1–9, January 1954.

This is a review of the author's experience with cancer of the tongue in 94 patients seen during a twelve-year period (1936–1948). Far-advanced cases, as well as some which were unsuccessfully treated elsewhere, are included.

An overall five-year cure rate of 31.9 per cent was obtained in this series of 94 patients. None were submitted to radical tongue surgery nor to a primary block dissection.

In the 30 successfully treated patients, radium implants of low-intensity needles were utilized in the primary lesion. The implants were maintained for seven days, and x-ray therapy, when used, was given simultaneously. Six to twelve thousand gamma roentgens were delivered throughout the involved areas. In this group of 30 cases palpable lymph nodes were treated in 10 cases (5 had nodes at the time of admission and in the remaining 5 the nodes appeared at a later date). In the entire group of 94 patients, 56 had combined radium needle and x-ray therapy to involved cervical lymph nodes. Of these, 17.8 per cent had a four-year survival; some others died of miscellaneous causes, free of cancer.

Complete healing of the primary lesion in the tongue was obtained in 71.2 per cent of the entire series.

Sixteen photographs; 6 tables.

RICHARD E. OTTOMAN, M.D.
University of California, L. A.

Intrinsic Cancer of the Larynx, 1942–1949. Walter L. Mattick and Anthony J. Mancini. Arch. Otolaryng. **59:** 71–75, January 1954.

During the years 1942 through 1949, 213 cases of cancer in and about the larynx were seen at the Roswell Park Memorial Institute, Buffalo, N. Y. Eighty-six, or 40.4 per cent, were classed as intrinsic, and 127, or 59.6 per cent, as extrinsic. The present report is devoted to the cases with intrinsic involvement. Of the 86 patients in this group, 83 were males and 3 females; 73 per cent were in the fifth and sixth decades. All of the neoplasms were squamous-cell carcinomas, 47 Grade I, 34 Grade II, and 5 Grade III. So far as possible, patients with the more differentiated types of carcinoma and those clinically free of neck node metastasis, and whose general health did not contraindicate it, were selected for surgery. Irradiation was employed in those with anaplastic tumors or metastatic neck nodes, those refusing surgery, and those for whom surgery was contraindicated. Tracheotomy was performed in some of these cases because of marked respiratory obstruction and in some others in anticipation of the obstructive edema and swelling often incident to radiotherapy. The concentration method of x-ray therapy suggested by Cutler and Lenz (See Am. J. Roentgenol. **51:** 739, 1944; J.A.M.A. **134:** 117, 1947. Abst. in Radiology **44:** 102, 1945; **50:** 432, 1948) was generally used.

In 36 per cent of the determinate cases without neck node involvement there was freedom from disease five years or more after surgical or radiation therapy. Of those with nodes, only 4.5 per cent were free of disease at five years. In 36 Group I cases, the five-year cure rate for 14 patients treated by laryngofissure and laryngectomy was 71 per cent; in 19 cases treated by irradiation the five-year cure rate was 13 per cent (18.7 per cent if 3 recurrent cases are deducted). In 9 cases treated by irradiation in which no tracheostomy was required, the five-year cure rate was 25 per cent.

One chart; 6 tables.

Malignant Tumors of the Thyroid Gland. H. Welti and G. Rusch. Schweiz. med. Wchnschr. **84:** 118–125, Jan. 16, 1954. (In French)

The authors report on 233 cancers of the thyroid found in 8,000 thyroid operations done in Paris from 1930 to 1950. The proportion of cancer to benign goiter was 2.9 per cent. The 233 cases included 69 relatively benign lesions: 34 papillary epitheliomas and 35 Langhans adenomas. The *papillary epitheliomas* are found especially in younger patients, and have a long survival rate. They give rise to the so-called "aberrant thyroid" tissue in the cervical lymph nodes, which is to be regarded as metastatic from a primary tumor in the thyroid gland and not as thyroid rests. Of the 34 cases, 33 were treated by radical surgery. A postoperative radium collar seemed to be beneficial.

The gross form of the *Langhans tumor* is characteristic—a fleshy adenoma with a cicatricial central zone and peripheral fleshy segments that converge toward the center. This type remains encapsulated for a long time, and excellent results are obtained with total resection of the affected lobe. Node resection is not necessary.

The more malignant tumors included 23 typical cancers, 132 atypical cancers, and 9 miscellaneous tumors. In the *typical cancers* the mortality rises

according to the stage of the disease, but the prognosis in this group is rather good.

The *atypical cancers* are usually seen in a later stage, and the prognosis is poor. When the tumor has broken through its capsule and is accompanied by node involvement, recurrence is to be expected regardless of the extent of surgery and the intensity of irradiation.

The *miscellaneous group* consisted of 4 sarcomas, already far advanced when first seen, and 5 metastases, of which 4 were from hypernephroma and 1 melanoma.

For Stage I thyroid cancers (intracapsular without adenopathy), total resection of the affected lobe without node dissection suffices, followed by radium therapy. The muscles overlying the affected lobe are resected with it. For Stage II (tumor intracapsular, but with adenopathy, or in part extracapsular but without adenopathy), removal of the affected lobe is supplemented by bilateral block neck dissection including the internal jugular vein. It is to be noted that, except in the papillary epitheliomas, the lymphatic route of spread is not important compared with the venous. Prophylactic node dissection, therefore, is not recommended. For Stage III (extracapsular extension into the soft parts) the surgical treatment is as in Stage II.

Postoperative irradiation seems to be of benefit in cases of thyroid cancer. Radium in a collar is to be preferred to roentgen therapy because the long protraction makes for a better chance of irradiating the slowly proliferating cancer cells during their most sensitive phases. The total dose varies between 300 and 400 microcuries. The collars are left in place night and day from four to seven days, with rest phases of twenty-four to seventy-two hours.

Results of treatment were as follows: for Stage I, 78 cures (18 for three years and 60 for more than five years), 9 failures; for Stage II, 23 cures (22 for more than five years), 20 failures; for Stage III, 10 cures and 38 failures; of those "cured" only 3 lived longer than five years.

Three tables.

CHRISTIAN V. CIMMINO, M.D.
Fredericksburg, Va.

Malignant Lesions of the Thyroid. Morley Cohen and George E. Moore. Surgery **35:** 62–76, January 1954.

This review of 101 cases of histologically confirmed malignant lesions of the thyroid covers the period from June 1924 to June 1952. Metastases were present in 36 cases when first seen. These were regional in 16 patients and distant in 20. Females predominated. Of the 28 men with thyroid cancer, 10 had non-toxic multinodular goiters.

A palpable lesion was present in 96 of the 101 cases; almost one-half of the patients had pressure symptoms. Signs, symptoms, and laboratory evidence of thyrotoxicosis were present in 10 per cent of the group.

Sixty-four patients were submitted to a major surgical procedure. Forty-six of these received a full course of radiation therapy postoperatively, and most of those who were not operated upon were given some radiation therapy, but details of technic and dosage are not included.

Twenty-six patients were given tracer doses of I^{131}, and 7 received therapeutic doses, but the highest uptake was only 29 per cent. Two cases of special interest are reported. In one patient who had metastatic carcinoma following an earlier subtotal thyroidectomy and roentgen therapy, a combination of isotope therapy and surgical excision of residual tumor produced "encouraging" palliation. In the other patient, also, surgery and isotope therapy combined to produce a good palliative effect.

Excluding 3 cases of lymphoblastoma, the survival rates for the series were: three years, 47 per cent; five years, 34 per cent; ten years, 24 per cent; fifteen years, 14 per cent. The histologic nature of the tumor is a significant factor in prognosis. Thus, for 56 "well differentiated" cancers the three and five-year survival rates were 76 and 57 per cent respectively, while for 42 "poorly differentiated" cancers the corresponding figures were 12 and 10 per cent.

One drawing; 15 tables.

RICHARD E. OTTOMAN, M.D.
University of California, L. A.

Struma Lymphomatosa: Clinical Manifestations and Response to Therapy. Walter E. Furr, Jr., and George Crile, Jr. J. Clin. Endocrinol. & Metab. **14:** 79–86, January 1954.

The authors review 62 cases of struma lymphomatosa, a clinicopathologic entity the cause of which remains unknown. In recent years, some have considered it to be a degenerative disease in contrast to earlier views that it was of inflammatory origin. The treatment, also, remains in dispute.

The great majority of the patients (90 per cent) were women. Symptoms varied, but were related either directly or indirectly to the goiter. Associated pathologic conditions in the vocal cord were common, and laryngeal examination is recommended in all patients with hoarseness. The most frequent misdiagnosis was nodular goiter; 40 per cent of the cases were so diagnosed preoperatively. The basal metabolic rate was zero or below in 39 of 49 cases studied, with clinical myxedema present in only 6 instances. Radioactive iodine uptake was usually normal.

The process may be present for years without change; in this series, 15 patients gave a history of goiter for ten years or more. Biopsy of one gland was repeated after a twenty-one-year interval, and the findings were essentially the same as they had been initially. Cases were graded histopathologically as to degree of lymphocyte infiltration, fibrosis, and lymph nodule formation. It was noted that marked lymphocyte infiltration was more frequent in goiters showing recent increase in size, and in those present for two years or less.

Results of treatment in 26 patients in whom the diagnosis was established by needle biopsy are presented. Eleven received x-ray therapy in doses ranging from 450 to 2,400 r, the goiter usually being reduced approximately 50 per cent in size in one to two months. A smaller group was treated with cortisone, the action of which may be similar to that of x-rays, producing its effect by lymphocytolysis. A maintenance dose of 2 to 3 grains of desiccated thyroid daily, given to 12 patients, proved an effective treatment, 50 per cent decrease in gland size being usually seen in from four to six months. The presumed mechanism of action in these cases follows the supposition that there is an excess of pituitary thyroid-stimulating hormone, which may be accompanied by lymphoid hyperplasia. Desiccated thyroid could then exert its effect by depressing this hormonal production.

Operation for struma lymphomatosa is not often necessary.

Seven tables. C. M. GREENWALD, M.D.
Cleveland Clinic

Rotation Therapy for Carcinoma of the Esophagus-Comparison of the Depth Dose with 200 kv. and 31 mv. H. Etter. Radiol. clin. **23:** 41–56, January 1954. (In German)

This paper is in two parts. In the first, an apparatus for rotation therapy is described for irradiation of the patient lying down, which can be employed with the usual method of fixed fields without change. The author's experience with rotation therapy of carcinoma of the esophagus in 54 patients during a three and one-half year period is reported. (1) Eleven patients received less than 9,000 r (air dose in rotation axis), with an average survival of 3.4 months. (2) Eleven patients received between 9,000 and 11,000 r, with an average survival of 5.2 months. (3) In 12 cases rotation therapy was combined with use of a radium sound, with an average survival of 7 months. (4) Twenty cases received between 11,000 and 14,000 r, with 9 survivals for an average of 11.9 months and 11 patients alive at the time of the report from one to thirty months. The value of sounds in the esophagus for prevention of cicatricial stenosis from the irradiation is emphasized.

In the second part of the paper, the depth dose from 200-kv. rays with cross-fire and rotation therapy is compared with that for 31 mv. The 31-mv. irradiation with cross-fire is about as effective as rotation irradiation with 200 kv. With either technic, a sufficiently high depth dose can be given with sparing of the surrounding tissues, but metastases are not prevented.

Nineteen roentgenograms; 1 photograph; charts and diagrams. CHRISTIAN V. CIMMINO, M.D.
Fredericksburg, Va.

Surgical and Radiological Results in the Treatment of Esophageal Carcinoma. Franz Buschke. Am. J. Roentgenol. **71:** 9–21, January 1954.

The author attempts to compare the surgical results in carcinoma of the esophagus as reported by Sweet with the results attained by several radiation therapists: Nielsen, Gynning, Smithers, and Watson. The material is relatively comparable inasmuch as Sweet explores 86 per cent of all patients seen, which is comparable to Nielsen's treatment of 90 per cent of patients seen. Comparison of the statistical five-year cure rates of the groups treated surgically and by irradiation shows them to be essentially the same, approximately 3 to 6 per cent of patients "sufficiently" treated (resection or thorough irradiation). When more rigorous surgical selection of patients is introduced, the five-year cure rate increases to 12 per cent of all patients explored (Garlock), and 28 per cent of all patients with resectable lesions.

For the vast majority of patients with epidermoid carcinoma of the esophagus, the problem is one of palliation. It appears justifiable, on the basis of symptom-free survival (with restoration of esophageal function), to conclude from the statistics presented that satisfactory results during the first three years are the same whether treatment is by surgical resection with anastomosis or by adequate roentgen irradiation.

Certain factors aid in the selection of surgery or radiotherapy in a given case.

First, the *gross appearance* of the lesion as seen *roentgenographically* gives a reliable lead. In the primarily constricting circular lesions the author feels that surgery is to be preferred, though radiation therapy should be considered when the surgical risk is great or when a segment of the esophagus less amenable to resection is involved. The exophytic carcinomas are difficult to eradicate either by surgery or radiation, since, by the time of discovery, they have usually metastasized to regional nodes. In general, radiation will offer as good a chance towards sterilization of the area as surgery, with less morbidity. The rather superficial mucosal carcinomas presenting as flat, large, ulcerating lesions are unsuitable for surgery, since they are prone to widespread dissemination. Cure by either surgery or radiation is rare. At times it may be desirable to withhold treatment except in the form of antibiotics to control the infection at the ulcer site, since this type of lesion is not obstructive and tends to perforate through the esophageal wall.

A second important point is the *level of the esophagus involved*. The primary surgical mortality is usually higher in cases requiring a supra-aortic anastomosis than with infra-aortic anastomosis. This would tend to weigh in favor of radiation therapy for supra-aortic esophageal carcinomas, other factors being equal.

A third factor influencing the decision is *age*. The primary surgical mortality is 6 per cent in patients under forty-five years, rising to 25 per cent above the age of sixty-five. Therefore, radiotherapy should have increasing preference with increasing age.

The author does not foresee any marked improvement in the overall result. He feels that certain limitations of curability for the majority of cases are inherent in the biological character of the disease with its late recognition and its tendency to spread to the regional lymph nodes.

References to the series upon which the author's study is based are as follows: Sweet: Surgery **23:** 952, 1948, and Surg., Gynec. & Obst. **94:** 46, 1952; Garlock: Harlem Hosp. Bull. **4:** 69, 1951; Gynning: Acta radiol. **35:** 428, 1951 (Abst. in Radiology **58:** 625, 1952); Nielsen: Acta radiol. **26:** 361, 1945 (Abst. in Radiology **47:** 100, 1946); Smithers: Brit. J. Radiol. **16:** 317, 1943 (Abst. in Radiology **43:** 315, 1944); Watson and Brown: J. Thoracic Surg. **22:** 216, 1951 (Abst. in Radiology **59:** 151, 1952).

Five tables. RICHARD E. OTTOMAN, M.D.
Los Angeles, Calif.

Radiation Management of Otherwise Hopeless Thoracic Neoplasms. Lewis L. Haas, Roger A. Harvey, and Seymour S. Langer. J.A.M.A. **154:** 323–326, Jan. 23, 1954.

The term "hopeless" is usually applied to thoracic neoplasms when they are inoperable, though it is known that some surgically hopeless cases can be cured by radiation and that in others palliation can be obtained by that means. The authors report their experience with the 23-mev betatron x-ray beam, as well as with conventional roentgen irradiation in so-called "hopeless" chest tumors originating in the lung and esophagus.

The palliative effect is judged on the basis of (1) the local effect as determined by physical examination, roentgenography, and study of pathologic material

at biopsy or autopsy; (2) clinical criteria, as pain, medication required, dysphagia, alteration in habits, etc.; (3) well-being as measured by weight, strength, ability to work, etc.; (4) absolute survival time following institution of irradiation; (5) extent of terminal distress.

The lung tumors treated favorably by the betatron included Pancoast tumors and upper bronchial lesions. The most gratifying results were measured in terms of clinical symptoms. Pain, dyspnea, cough, and expectoration frequently subsided or diminished, and some patients were able to resume their usual way of life. In fatal cases the terminal agony was relatively shortened. Results in esophageal tumors were less striking but hopeful.

A large number of patients with similar lesions were treated with 200 and 400 kv. Some difference in results was found, which is attributed to the more adequate and uniform depth dose obtained with the betatron.

The authors feel that no patient should be denied radiation therapy unless he has reached a terminal status. While high-voltage therapy is to be preferred, conventional irradiation in adequate dosage is productive of palliation as measured by the criteria cited above. As high a tumor dose as possible is given within the tolerance of the individual.

Thirteen roentgenograms; 1 photograph.

DONALD DEF. BAUER, M.D.
Coos Bay, Ore.

Radiotherapy for Inoperable Glands from Squamous-Cell Carcinoma. John R. Nuttall. J. Fac. Radiologists **5**: 102–111, October 1953.

The problem of lymph-node metastases from squamous-cell carcinoma is a familiar one to the radiologist. The object of treatment may be cure of comparatively small and superficial nodes, relief of pressure symptoms due to larger deep-seated masses, or prevention of ulceration and fungation. A more severe reaction and high-dosage to a limited volume are practicable only in the cases where cure is the aim. Curative therapy is practically limited to the superficial group of nodes.

Pelvic, thoracic, and abdominal nodes cannot safely be given curative doses. Useful palliation may be obtained, however, in mediastinal compression from lymph node involvement and in metastases from late cancer of the cervix.

Tumor restraint rather than cure is usually the best that can be obtained in inguinal node involvement. The response here is poor, and reactions are severe.

Axillary nodes are more inaccessible than those in the groin but afford better results. For low axillary nodes, a volume or two-plane radium implant may be successfully employed, but it is almost impossible to implant the apex satisfactorily. Similar results may be obtained from external irradiation applied to single low-lying nodes surgically exposed. Occasionally wider external irradiation produces a good result. The author uses anterior axillary and direct axillary ports (90° angle attained by use of a jig) in thin patients and adds a posterior axillary field in obese patients. He stresses use of fields at right angles rather than "normal" to the skin to secure more homogeneous irradiation. Isodose curves of the fields are shown.

Pre-auricular and epitrochlear nodes—nearly always secondary to cutaneous cancer—are superficial and lie on a bony bed. They respond well to external irradiation or a single plane radium implant with the same dose level as is used for the primary lesion.

For cervical lymph nodes the methods of treatment producing the majority of satisfactory results are radium needle implantation, external irradiation, and a combination of external and interstitial therapy. The last two methods have been most useful in the author's hands, but only about 12 per cent of the patients treated survived more than three years. For palliation in the presence of large fixed masses in the neck, 200-kv. x-rays have been used with half to two-thirds of the usual cancer dose. Considerable symptomatic relief has been thus obtained.

Several points are stressed regarding treatment policy for cervical nodes.

1. Irradiation at the site of a previous unsuccessful block dissection probably never cures.
2. Preoperative irradiation does not convert inoperable into operable nodes. Subsequent surgery does not cure, and risk of dissemination is high.
3. Radon seed implants in the author's hands produced painful reactions, did not cure, and led to dissemination of cancer.
4. Cervical lymph nodes vary widely in their responsiveness, and every case is somewhat of an experiment. Much depends upon location and dose actually received, a factor which at times is quite unreliable.
5. Lymph nodes in the upper and middle thirds of neck are more amenable to treatment than those in the lower third, because of their accessibility and the fact that the skin here is less easily damaged.
6. A single mass is the most profitable lesion to treat. Through-and-through irradiation of bilateral masses is usually disappointing, as is implantion of the entire carotid chain.
7. It is impracticable to treat a volume greater than one-quarter of the neck with a dose sufficient to cure.

Five illustrations.

DONALD OTTO, M.D.
Detroit, Mich.

Treatment of Hodgkin's Disease and the Lymphosarcomas. Ovid O. Meyer. J.A.M.A. **154**: 114–120, Jan. 9, 1954.

The author discusses his experiences in treating patients having Hodgkin's disease, the lymphoid-cell type of lymphosarcoma, follicular lymphoblastoma, and reticulum-cell sarcoma. Commenting upon the conflicting theories of the etiology of Hodgkin's disease, he agrees with Piney that it is a disease of the reticuloendothelial system. His classification of the types of Hodgkin's disease is like that of Jackson and Parker, and includes paragranuloma, granuloma, and Hodgkin's sarcoma. Although this classification lists the types in order of increasing severity and diminishing prognosis, it is accepted that paragranuloma may at any time undergo transition to granuloma, and a granuloma may terminate as Hodgkin's sarcoma.

X-ray therapy is still considered to be the treatment of choice in most instances of Hodgkin's disease, lymphosarcoma, reticulum-cell sarcoma, and follicular lymphoblastoma, the last being the most roentgensensitive. High-voltage therapy is directed to all detectable sites of disease, but not more than two fields are treated per day, receiving 150 r to 200 r (in air) each (not exceeding a total of 1,600 to 2,000 r per field). The depressant effect of radiation upon the bone marrow necessitates close observation of the leukocyte

count. Radioactive phosphorus is considered to be unsatisfactory for treatment of diseases of the reticuloendothelial tissues, in contrast to its effectiveness in treatment of afflictions of the myeloid tissues. Radium is rarely used.

Nitrogen mustard is considered valuable in the treatment of Hodgkin's disease, particularly when widespread systemic disease exists or when the patient has become insensitive to radiation therapy. Occasionally responsiveness to roentgen therapy may be restored following treatment with nitrogen mustard. The remissions induced by the drug are generally of shorter duration than those following irradiation. The margin of safety in the use of nitrogen mustard is narrow, and to avoid serious toxic effects upon the blood-forming organs, repeated courses of therapy are usually separated by at least six weeks. Nitrogen mustard is of less value in the treatment of lymphosarcomas and leukemias.

Triethylene melamine has an action which, like that of nitrogen mustard, depends upon transformation to an ethylenimonium compound. This, too, gave better results in Hodgkin's disease than in lymphosarcoma or lymphocytic leukemia. Ultimately, as with nitrogen mustard, a refractoriness developed in most patients. The author believes that roentgen therapy is best when there is localized disease, but that triethylene melamine is the most suitable therapy available for generalized systemic disease.

Steroid therapy with cortisone or corticotropin produced effects that were mainly slight and transient. Surgical excision is indicated for treatment of lymphosarcoma and reticulum-cell sarcoma, and possibly a rare case of follicular lymphoblastoma, if a localized mass is demonstrated early before metastasis has occurred. In the author's experience with over 300 cases of Hodgkin's disease, he found none early enough or sufficiently localized to justify surgery. A case is reported in which a hemolytic anemia complicated Hodgkin's disease and was promptly relieved following splenectomy.

Important adjuvants in treatment include a high-calorie, well balanced diet, administration of iron, transfusions as necessary, antibiotics at times, and the maintenance of good morale by permitting reasonable activity during asymptomatic phases and by avoiding a pessimistic attitude and an ominous or specific prognosis.

Four roentgenograms, 2 photomicrographs.

ARTHUR S. TUCKER, M.D.
Cleveland Clinic

The Use of Radium in the Treatment of Benign Lesions of the Uterus: A Critical Twenty-Year Survey. Robert M. Hunter, N. Volney Ludwick, John F. Motley, and Wilbur W. Oaks. Am. J. Obst. & Gynec. **67:** 121–129, January 1954.

In view of the recent trend toward hysterectomy as the definitive treatment for benign uterine lesions in the perimenopausal period, the records of 644 patients treated with radium at Hahnemann Hospital (Philadelphia) from 1932 to 1950 were reviewed. These radium-treated patients were followed for two to twenty years.

The authors believe that, when definitive therapy is required for dysfunctional uterine bleeding or minimal myomata in women at or about the menopause, radium is the agent of choice, being safe and effective. No conclusions are reached concerning the specific problem of when radium therapy shall be used.

Of patients in the age group thirty-five to fifty-four with a diagnosis of dysfunctional uterine bleeding and myomas, 93 per cent were treated successfully. Since 1947 over 75 per cent of the patients treated for benign lesions of the uterus have received over 2,000 mg.-hours each. With this increased "routine dose," there have been no failures.

The validity of conclusions in the literature that the incidence of carcinoma of the uterus will be significantly higher in radium-treated patients is questioned. In only 3 patients in this series, did post-irradiation pelvic cancer develop.

Objections and contraindications to radiotherapeutic castration are discussed. The authors urge a more conservative and rational approach to the treatment of these benign lesions with the thought that presentation of actual clinical data will alleviate some of the concern over the alleged high incidence of post-irradiation cancer "inferred by statistical prognostication."

Five tables; two graphs.

ROBERT L. EGAN, M.D.
Jefferson Medical College

Two Years of Research and Experience with the 31-MeV Betatron at the Kanton Hospital in Zürich. H. R. Schinz. Fortschr. a. d. Geb. d. Röntgenstrahlen **80:** 1–28, January 1954. (In German)

Comparisons are made of radiation of 200 kv., 800 kv., and 31 mev. A certain depth dose at 8 cm. was selected as 100 per cent. To achieve this dose with 200-kv., 250 per cent would be required on the skin and the exit dose at 16 cm. would be 20 per cent. At 800 kv., the surface dose would be 160 per cent and the exit dose 45 per cent. With 31 mev (betatron), the input dose would be 20 per cent and the exit dose 80 per cent. Thus the betatron delivers relatively little surface dose but a heavy exit dose. The greatest dose per cent is at approximately 5 cm. depth. The betatron gives a narrow, sharply defined area of irradiation. The half-value layer in copper is 1 mm. for the 200 kv. rays and 30 mm. for the 31-mev radiation.

The isodose curves comparing the three types of radiation show definite improvement in the depth dose with 31 mev, as much as 60 per cent reaching a depth of between 20 and 25 cm. The energy absorption per gram of tissue is practically identical in muscle, bone, etc. The volume dose is much smaller than given by the conventional cross-fire technic.

The betatron in the author's laboratory delivers 50 impulses per second, the ratio of the impulse time to the irradiation-free interval is 1:2,000. The impulse lasts 10 microseconds. Each individual impulse represents 10 milliroentgens.

The physics of the radiation and results of photoionization and measurements in various materials are discussed, and biological effects on various organisms are compared with those of 200- and 800-kv. radiation. Numerous cases are cited to show the method of application, two of which are summarized as examples of this type of work.

A carcinoma of the vulva was treated through a 12 × 15-cm. field at 100 cm. distance, for forty-nine days, with 300 r daily, for a dose of 8,940 r at a depth of 3.5 cm. A light mucosal reaction was noticed and the tumor completely disappeared. There was local recurrence at a later date, with death nine months after completion of the treatments.

A carcinoma in the postcricoid, region, Stage III, had previously been treated with 180 kv., receiving a total dose of 4,080 r divided between the two sides of the neck. Betatron treatment was given, 3,960 r at a depth of 5.3 cm. through the right side. A moderate erythema developed on the right and an exudative reaction on the left. At the last observation the lesion appeared to be healed.

Examples are also given of excellent response to treatment by bladder and other deep-seated tumors.

The author tabulates the following ten indications for the use of the betatron.

(1) Deep-seated lesions, especially in the bladder, kidney, uterus, vagina, ovary, pancreas, digestive tract, esophagus, trachea, and bronchi.

(2) Tumors with overlying bone, as in the sinuses, epipharynx, base of tongue, hypophysis, brain, and spine.

(3) Extensive tumors of the hypopharynx and larynx without metastasis, in which it is important to avoid extensive skin damage and too great dosage to bone and cartilage.

(4) Cases in which it is of advantage to use a single field of application.

(5) Residual tumor after treatment with 200-kv. therapy with extensive skin reaction.

(6) Residual lesions after previous 200-kv. therapy with marked skin damage, without previous skin change (late result).

(7) After surgery when special skin protection is advisable.

(8) In patients reacting poorly to 200-kv. therapy.

(9) For palliation without hope of complete healing, to avoid general reaction.

(10) Distant deep-seated metastases after healing of the primary tumor.

Thirty-three illustrations. E. W. SPACKMAN, M.D.
Fort Worth, Texas

Biological Experiments with the 31-MeV Betatron. Hedi Fritz-Niggli. Fortschr. a. d. Geb. d. Röntgenstrahlen **80:** 28–38, January 1954. (In German)

The author seeks to estimate the difference in biological effect between the radiation produced by 31-mev betatron and conventional 180-kv. x-rays. The descriptive material is highly technical and the reader is referred to the original article for details of the experimental procedures. Plexiglass phantoms were used and the depth of the specimens was varied. For the betatron a depth of 41 mm. was selected, and for the 180-kv. therapy machine 13 mm. Measurements were made with a Victoreen meter.

Drosophila eggs and pupae, *Vicia faba*, and mice were used as test materials, and charts comparing the effects of the two types of radiation are given. In some cases differences in effect have been observed, the ultra-hard radiation apparently being less effective. This was particularly striking in mice, which appeared to survive the betatron therapy longer than the 180 kv.

The author believes that a definite decision regarding the value of the ultra-hard radiation as compared to the conventional type of radiation cannot be made at present. He suggests that betatron radiation may have varying effects due to environmental changes such as the *p*H, oxygen tension, etc.

Seventeen illustrations. E. W. SPACKMAN, M.D.
Fort Worth, Texas

RADIOISOTOPES

Results of Therapy with Radioactive Iodine in Hyperthyroidism. Richard E. Goldsmith and Eugene L. Saenger. Ohio State M. J. **50:** 26–27, January 1954.

This is a report on 22 patients seen and treated in the Radioisotope Laboratory of the Cincinnati General Hospital and followed by one person from four to twenty months. This selection was made to insure uniformity in diagnosis, in interpretation of physical findings, and in the follow-up. All of the patients had fairly typical thyrotoxicosis clinically, and all had radioiodine tracer studies suggesting an overactive thyroid. Four patients had previously been treated surgically for thyrotoxicosis. Two had previously been given relatively small doses of radioisotopes and then had been lost to follow-up for one or more years; they were not considered treatment failures. Several patients had received stable I^{127} and/or antithyroid drugs. Fourteen patients had diffuse goiters, 7 had multinodular goiter and 1 had no goiter. The diffuse goiters ranged in estimated weight from 30 to 120 grams, and the multinodular goiters from 40 to 100 grams. The average dose of I^{131} for the patients with diffuse goiters was 11.4 millicuries and for those with multinodular goiters 16.0 millicuries.

All of the patients showed excellent clinical responses and are now euthyroid. The response to therapy was as prompt as with surgical treatment when surgical preparation and postsurgical convalescence are considered. The response in the patients with multinodular goiter was as satisfactory as that in patients with diffuse goiter. There were no complications or unwanted sequelae except for myxedema in 1 patient. No patient showed a true resistance to the I^{131} therapy, although multiple doses were required in 5 cases.

Ten Years' Experience with Radioactive Iodide. Earle M. Chapman, Farahe Maloof, Jorge Maisterrena, and Jorge M. Martin. J. Clin. Endocrinol. & Metab. **14:** 45–55, January 1954.

From a study of 400 patients treated with I^{131} from 1946 through 1952, the authors conclude that this isotope is effective in the control of hyperthyroidism caused by a diffusely hyperplastic thyroid. They believe that it should not be used for treatment of nodular goiter because of the high incidence of carcinoma in such cases.

A dosage of 160 microcuries per estimated gram of thyroid has been arrived at, based on the assumed average 48-hour retention of 70 per cent of a previous tracer dose. The average interval before the basal metabolism rate became normal was two months; 75 per cent of the patients responded to a single treatment. Since the biological response is gradual, six to twelve months was allowed to elapse before considering a second dose. In only 8 per cent of the patients

did myxedema develop; the average dose causing this condition was 8 millicuries, and the usual interval before its appearance was four months, though myxedema has been known to appear years after the original cell injury. The authors believe that patience in awaiting response before giving a second dose contributed to the low incidence in this series.

Indices of function were seen to return to normal only to rise again shortly in patients with thyrotoxicosis who received an inadequate initial dose. This type of case is not considered a recurrence but as persistent disease. There was no recurrence after a patient had remained euthyroid for several months.

Calcium metabolism is in a state of flux during hyperthyroidism, and about 20 patients were noted to have a concomitant bursitis.

Doubt is raised as to the wisdom of administering larger doses (250 microcuries per estimated gram of thyroid) in people over forty, as recommended by some, there being perhaps a tendency for natural decline in function which, combined with treatment, might increase the incidence of myxedema.

The tracer uptake, protein-bound iodine (PBI), and basal metabolism rate normally follow standard patterns. Unexplained dissociation of these indices of function, however, was seen in a group of toxic patients with a high basal metabolism rate and PBI, but with normal uptake of I^{131}. A second group of apparently euthyroid patients with normal metabolism had a low PBI and I^{131} uptake under 20 per cent.

I^{131} radiation produces fibrosis and cellular damage in the thyroid, resulting in bizarre nuclear forms; yet some of the remaining follicles appear hyperplastic. Histologic section from 44 thyroids studied after treatment revealed no evidence of malignancy.

The authors briefly outline a late follow-up on 45 cases treated with I^{130} prior to 1946.

One photomicrograph; 7 graphs; 4 tables.

C. M. GREENWALD, M.D.
Cleveland Clinic

Radioiodine Treatment of Thyrotoxicosis: A Single Dose Method Following a Drug Preparation. Russell Fraser, John D. Abbatt, and F. S. Stewart. Brit. J. Radiol. **27**: 23–30, January 1954.

Because of the difficulty of assessing the size of the thyroid accurately and the uncertainty of distribution and retention of radioiodine in thyrotoxicosis, and in view of the difficulties encountered with repeated doses, the authors give preliminary drug therapy followed by a single dose of radioiodine.

The patient is given 600 mg. methylthiouracil and 0.1 mg. *l*-thyroxine daily for six weeks (sometimes longer if he has not become euthyroid). This is followed by two weeks of daily doses of 15 mg. Neomercazole and 0.15 to 0.3 mg. *l*-thyroxine. Four days after this course radioiodine is administered in dosage sufficient to give 150 to 250 microcuries per gram of gland.

Whether the drug preparation has helped stabilize the irradiation dosage is unproved, but the management of the patient is facilitated. At the end of one year, of 32 patients so treated, 26 showed remissions, 5 needed more treatment, and 1 had permanent myxedema. The authors are experimenting further with the administration of *l*-thyroxine following the radioiodine dose.

SYDNEY J. HAWLEY, M.D.
Seattle, Wash.

Experiences of Management and Treatment of Polycythaemia Vera Using P^{32} as a Therapeutic Weapon. John D. Abbatt. J. Fac. Radiologists **5**: 141–147, October 1953.

Twenty-five patients ranging in age from thirty-seven to eighty-two years were treated with P^{32} at Hammersmith Hospital, London, long enough ago for a preliminary assessment of results. Treatment consisted of an initial single intravenous injection of 5 to 7 millicuries of P^{32} after careful hematologic assessment. Venesection is used only if immediate symptomatic relief is needed. Patients are followed at weekly intervals. Particular care is taken to obtain accurate platelet counts.

The full response is not manifest for a variable period, which may be as long as four months after the initial treatment. Symptomatic response frequently precedes objective evidence. The platelets are the first cellular element to be depressed, reaching the lowest level at four weeks and rising rapidly thereafter. Using values of 150,000 to 350,000 per cubic millimeter as normal, it was found that a fall to 50,000 platelets/c.mm. or less was invariably followed by a full remission. (As platelet depression is of short duration, weekly counts are mandatory, or the depression may be missed and it may be mistakenly assumed that no response has occurred.) If this observation can be confirmed, the platelet response may be used as a guide for dosage required to produce a full remission.

The white count begins to fall shortly after the platelet depression and is followed by a reduction in the hematocrit, usually beginning four to six weeks after injection or later.

Remissions are of variable duration and there is wide individual variation in the dose required for their production. The criteria of full remission are complete absence of all symptoms and signs of the disease together with a normal blood picture for a period of six months or longer. Using these criteria the following results were obtained in the author's series.

No response	1
Symptomatic response (without full remission of signs)	4
Full remission (6 months or longer)	20

Four graphs.

DONALD OTTO, M.D.
Detroit, Mich.

An Evaluation of the Clinical Use of a Strontium^{90} Beta-ray Applicator with a Review of the Underlying Principles. H. L. Friedell, C. I. Thomas, and J. S. Krohmer. Am. J. Roentgenol. **71**: 25–39, January 1954.

The authors present a summary of their four years experience with strontium beta-ray therapy. Their 137 cases comprise a wide variety of corneal lesions such as corneal vascularization, pterygium, vernal catarrh, tumors, and such infections as tuberculous sclerokeratitis.

Clinical use of beta-ray applicators requires a full understanding of the depth dose. Lesions deep in the cornea receive much smaller doses than lesions close to the surface. At 1.0 mm., for instance, the depth dose is only 41 per cent of the surface dose and at the depth of the lens, 3 per cent. Slit lamp examination is invaluable in determining the depth of the process and, therefore, in estimating the amount of radiation necessary for its adequate treatment.

In a study of the biologic effectiveness of the beta-ray applicator, it was found that dosages recorded in reps appear to approximate rather closely the dose in roentgens of low-voltage (44-kv. Philips' contact unit) roentgen-ray therapy. While the effectiveness of the beta-ray applicator has been in corneal diseases, the normal cornea is actually a poor structure for evaluation of the biologic effectiveness of the beta-ray because of its avascularity and high collagen content. At the low radiation dosages utilized clinically, the vascularized corneal areas are much more sensitive than the normal areas.

Since their original studies (see, for example, Am. J. Ophth. **33**: 525, 1950. Abst. in Radiology **56**: 792, 1951) the authors have found that, in order to affect most processes, considerably larger doses of beta radiation have become necessary. They attempt to distribute the radiation in the region of the limbus as much as possible and to give as little as possible to the central corneal zone as is clinically feasible. They incorporate a note of caution indicating that high doses (16,000 to 17,000 reps) in the region of the limbus may predispose to glaucoma by virtue of induced fibrosis in the region of Schlemm's canal or by destruction of the aqueous veins in this area. The following table summarizes the authors' current dosage schedule for beta radiation:

SUMMARY OF DOSAGE SCHEDULE FOR BETA RADIATION

Type of Lesion	Dose per Treatment in Surface rep	Interval	Total Average Dose in Surface rep
Vascularization			
Superficial			
Prekeratoplasty	1,800	Weekly	7,200
Postkeratoplasty	1,200 or 1,800	2–3 days	4,800 to 6,000
Deep / Mixed	1,800	Weekly	10,800
Pterygia			
Preoperative (reserved for thin, flat, or early recurrence)	1,800	Weekly	12,000
Postoperative	600 to 1,200	Weekly	4,000 to 6,000
Vernal Catarrh			
Limbal	1,200	Weekly	4,800 to 6,000
Palpebral	1,800	Bi-weekly*	9,000
Tumor			
Papilloma			
Eyelid	1,200	Weekly	6,000
Conjunctiva	1,800	Weekly	7,200 to 9,000
Hemangioma	1,200	Monthly	3,600
Chalazion	1,200	Weekly	3,600
Infection			
Tuberculous sclerokeratitis	1,800	Weekly	5,400 to 7,200

* Monthly treatments may also be used.

Sixteen photographs; 4 tables.

RICHARD E. OTTOMAN, M.D.
University of California, L. A.

Estimation of Intrinsic Factor of Castle by Use of Radioactive Vitamin B_{12}. Sheila T. Callender, Adam Turnbull, and Gyoichi Wakisaka. Brit. M. J. **1**: 10–13, Jan. 2, 1954.

The stomach secretes an intrinsic factor (Castle's factor) which is necessary for the absorption of vitamin B_{12} from the intestinal tract. Lack of absorption of this vitamin results in pernicious anemia.

Vitamin B_{12} tagged with radioactive cobalt was given to 10 normal subjects and to 13 patients with pernicious anemia, all but 2 of whom were in long-standing well treated remission states, and the absorption of the vitamin was then determined by measuring the radioactivity in the feces.

In the 10 normal subjects with normal hematologic findings, a mean of 31 per cent of the radioactive material was recovered in the feces. In the 13 patients with pernicious anemia, a mean of 88.7 per cent of the radioactive material was recovered. Then, to prove its role in promoting absorption of vitamin B_{12}, the intrinsic factor was given with the vitamin B_{12} to 8 of the pernicious anemia patients. The amount of radioactive material in the feces decreased markedly.

Four roentgenograms; 3 tables.

PAUL MASSIK, M.D.
Quincy, Mass.

Comparative Exchange of Calcium, Lead, and Radioactive Lead in Dogs. J. Alfred Calhoun, Regina McLean, J. Cramer Hudson, and Joseph C. Aub. Arch. Indust. Hyg. & Occup. Med. **9**: 9–22, January 1954.

Radioactive lead, used experimentally as an indicator for inert lead, was found to be toxic to dogs when injected intravenously in amounts ranging from 0.2 to 2.3×10^{-1} mc. per kilogram. Varying the amount of inert lead between 0.6 and 6.7 mg. per kilogram did not appear to influence the survival time. Toxicity seemed to be dependent upon the amount of radioactivity.

The average urinary excretion of tagged lead analyzed as radium D was roughly 67 per cent of the total excretion.

Parathyroid hormone, low calcium diet, or high calcium diet had no effect on excretion of tagged lead. This was not in agreement with previous findings with inert lead (Hunter and Aub: Quart. J. Med. **20**: 123, 1927). It is doubtful that the toxic effects of radiation seriously impaired the mechanism involved in the re-

sponse to parathyroid hormone, because this medication produced a satisfactory increase in calcium excretion.

As much as 60 to 80 per cent of the injected lead was excreted during the lifetime of the animals which survived some months. Only a small fraction of the stored lead was present in organs other than bone.

After some months uremia appeared to develop in the dogs given radioactive lead. Apparently the azotemia, leukopenia, and physical deterioration occurring in these animals were due to the radioactivity, since the injection of 1.9 and 2.7 mg. per kilogram of inert lead had no deleterious effects on the health of 2 other animals.

The clinical evidence of renal failure was more obvious than the pathological evidence. There were 5 cases of known terminal azotemia, yet only 3 animals showed histologic evidence of kidney damage. Indeed, 1 dog had a histologically normal kidney in spite of increased permeability of this organ for two months before death.

Three charts; 8 tables.

Maximum Permissible Concentration of Radioisotopes in Food, Water and Air and Maximum Permissible Equilibrium Amounts in the Body. Karl Z. Morgan. Acta radiol. **41**: 30–46, January 1954.

The author presents values for the maximum permissible body burden, Q, and the maximum permissible concentration, MPC, in air and water of some 70 radioisotopes. The MPC for food is the same as that for water. These values are taken from National Bureau of Standards (U. S.) *Handbook 52*, prepared by the National Committee on Radiation Protection. With the values given, no readily detectable biological damage would be expected to occur. However, due to the uncertainty inherent in these figures, the Committee recommends that a large factor of safety be allowed in the design and operation of permanent installations using large quantities of radioactive materials. A few of the values are based on experience with man, but most were calculated on the basis of data from animal experiments.

The value of Q is considered to be the microcuries of a radioisotope deposited in the whole body that will deliver 0.3 rem per week to the critical organ, *i.e.*, the one receiving the isotope that results in the greatest overall damage to the body. The MPC values are the concentrations of the radioisotopes in air or water that, if used exclusively for an extended time, will lead to an accumulation, Q, in the body. MPC values for air and water to be used in an emergency are also given.

A large dose of ionizing radiation is delivered to tissue in close proximity to an airborne particle of high specific activity that becomes fixed in living tissue. In setting the MPC values for air it would be helpful to know if such localized radiation increased the probability of tumor occurrence.

Two diagrams; 3 tables. JOHN J. CRAVEN, M.D.
Cleveland Clinic

Simplified Autoradiography Exposure Calculation. William W. Wainwright, Ernest C. Anderson, Preston C. Hammer, and Charles A. Lehman. Nucleonics **12**: 19–21, January 1954.

The importance of half-lives and emission energies of beta-emitting isotopes in connection with their use in autoradiography is emphasized in this article. The use of weak beta emitters improves the resolution available in autoradiographs. The use of longer half-lives is often advantageous in permitting more time for the conduct of the experiment. A number of commonly used beta emitters are plotted on a graph according to half-life and relative beta-ray range to illustrate the great differences between the various isotopes available.

The authors state that the formula developed by Axelrod and Hamilton (Am. J. Path. **23**: 389, 1947. Abst. in Radiology **50**: 437, 1948) for estimating exposure time is very useful. This relation indicates that between 2 million and 10 million beta particles striking the emulsion per square centimeter give a suitable exposure. A network chart is presented which relates the half-life of the isotope, the activity of the source, and the optimum exposure time. This chart has been constructed by the authors particularly for isotopes of short half-life, to which it is difficult to apply the Axelrod and Hamilton formula. Some details of the Geiger counter technics employed to measure the activity of the specimen are presented.

Four illustrations. JOHN S. LAUGHLIN, Ph.D.
Memorial Center, New York

RADIATION EFFECTS

Integral Dose, Body Size, and the Site of Irradiation as Factors Determining the Severity of Radiation Sickness. W. M. Court Brown and R. F. Mahler. J. Fac. Radiologists **5**: 200–209, January 1954.

The symptoms of radiation sickness fall into three phases: (1) the latent period, which is defined as the time which elapses from the commencement of irradiation to the onset of symptoms, (2) the period of acute symptoms, and (3) the recovery period. The object of the present paper is to examine the factors which may determine the length of the latent period, and to demonstrate that for a given anatomical site of irradiation the length of this period can be predicted with considerable accuracy by considering the integral dose per unit of body size. If the length of the latent period can be determined it can be shown that the duration and acuteness of the subsequent symptoms can also be predicted, although with less accuracy. The latent period has been found to vary in length from about one-half hour to between four and a half and five hours.

The effect of a single exposure to x-rays was studied in 82 patients, 76 per cent of whom developed symptoms. All were in-patients and confined to bed. Integral dose calculations were based on data obtained by Boag (Brit. J. Radiol. **18**: 235, 1945). Symptoms accepted as indicative of radiation sickness were nausea, vomiting, fatigue, and headache, although the latter two have also been encountered following sham irradiation.

The size of the patient was found to exert a strong influence on the length of the latent period, in that those patients with larger body surface areas have a longer latent period. Those patients who received irradiation to the abdomen appeared to have a higher incidence of radiation sickness than those in whom the upper half of the trunk was irradiated.

The duration of the acute symptoms and the severity

of these symptoms were found to be inversely related to the length of the latent period. It has been suggested that one possible explanation of these findings is that radiation releases a diffusible metabolite or metabolites. The length of the latent period and the duration and severity of the symptoms may be determined by the final concentrations of these agents in their volume of dilution, which may be the whole body or some particular fluid compartment.

Eight graphs.

C. R. McINTIRE, M.D.
Indiana University

The White Cell Count in Relation to Occupational Radiation Dosage. E. K. Williams. Acta radiol. **41:** 21–29, January 1954.

There is general agreement that the white blood cell count is a useful index of the effect of doses of radiation to the whole body. However, white blood cell counting has been shown to be subject to technical variation of 8 per cent when the count is 7,000 leukocytes per cubic millimeter. Moreover, physiological variations can be marked. Not only are there day to day variations, but emotional tension and exercise can cause a rise of the leukocyte count in a normal individual.

In a series of 3,098 pre-employment blood counts done at the Atomic Energy Research Establishment, Harwell, England, 6 per cent of leukocyte counts and 14 per cent of lymphocyte counts were below the levels of 5,000 and 1,500, respectively, which are given as the lower limits of normal in the 1943 edition of the "Recommendations of the British Roentgen-ray and Radium Protection Committee." A study of relative sickness rates failed to show any greater susceptibility to illness or any less favorable reaction to infection among persons with persistent leukopenia as compared to those with so-called normal leukocyte counts.

The author believes that in evaluating quantitative changes in white cell counts of the blood, these technical and physiological variations should be taken into account. Otherwise conclusions as to the contribution of radiation effect may be invalidated and the counting procedure fall into disrepute.

Lymphocytes are the most sensitive of the leukocytes, whether the exposure is acute or chronic. Even at average exposure levels of less than 0.5 r per year there was some slim statistical evidence of radiation effect on lymphocyte counts, and all workers receiving 0.2 r per week showed some effect. Cytologic changes in lymphocytes, especially an increased incidence of binucleate lymphocytes, appear to occur with very small amounts of radiation. Observation of these changes has been suggested as a sensitive adjunct to physical monitoring.

JOHN J. CRAVEN, M.D.
Cleveland Clinic

Fatal Panmyelopathy Produced by Thorotrast (Thorium Dioxide). S. Moeschlin, H. R. Marti, and W. Germann. Schweiz. med. Wchnschr. **83:** 1061–1063, Oct. 31, 1953. (In German)

Radioactive Thorotrast, which is used to visualize the liver and spleen and for arteriography, is stored in the reticulo-endothelial system. This stored Thorotrast may be the cause of tumors of the liver, cirrhosis, or changes in the blood. The authors report a case presenting the clinical pattern and autopsy findings of diffuse panmyelopathy.

The patient was a 74-year-old housewife in whom an arteriogram of the femoral artery had been obtained by means of 30 c.c. of Thorotrast (7.5 cm. ThO_2). Seven years later, a pancytopenia was present, with 1,560,000 erythrocytes, a leukopenia of 2,600, and a thrombocytopenia of 14,000. The sternal marrow biopsy disclosed a shift to the left with a predominance of promyelocytes and immature myelocytes. Autopsy disclosed deposits of thorium in the liver, spleen, and bone marrow. Radioactivity was increased ten- to twenty-fold as compared with normal.

Changes in the bones probably occurred slowly and, because of an intercurrent pneumonia, a decompensation developed. After the administration of penicillin, the patient recovered slightly and a predominantly myeloid reaction of the blood with a leukocytosis up to 12,000 cells was noted. It was assumed that these cells came from the spleen and liver, where many extramedullary hematopoietic foci were found. The thrombocytopenia was still marked, and the patient died because of severe hemorrhagic diathesis.

The authors review the literature and cite cases of aplastic anemia following injection of thorium. Roth (Deutsch. med. Wchnschr. **76:** 776, 1951) saw similar findings in a patient who worked for eleven years preparing radium substances. Others have described local granulomatous tumors after the injection of Thorotrast. There seems to be no doubt that the administration of this preparation should be considered as a dangerous procedure, since late effects—after six to twelve years—may develop.

Six photomicrographs; 2 graphs.

JULIAN O. SALIK, M.D.
Baltimore, Md.

Factors Influencing Recovery After Whole-Body Radiation. Edith Paterson. J. Fac. Radiologists **5:** 189–199, January 1954.

This paper describes an attempt to estimate the tolerance dose of irradiation given in a single session and to discover how tolerance is influenced by time factors. Some of the mechanisms that may be responsible for recovery or for death of an individual were examined. The data are derived mainly from experimental work with mice and with the Rhesus monkey.

The influence of the dose of radiation was studied from two aspects: (1) the 50 per cent lethal dose for a single exposure of x-rays and (2) the influence on the LD 50 of extending the overall time of irradiation. With massive single doses the survival rate and the survival time were correlated with dose. The mean survival time for mice varied between eleven and a half and thirteen days; for monkeys it was fourteen and a half days. It was found that a dose of 518 r produced a 50 per cent survival for irradiation given as a single session; this must be increased to 946 r if the overall time is extended to twenty days.

Peripheral blood counts upon irradiated monkeys showed no difference in the lymphocyte depression or the neutrophil count in surviving and non-surviving animals. The effect upon the red blood cell count was different in the two groups. In the surviving monkeys some of the counts were as low as in those that died, but the mean count in the surviving group was higher. The reticulocyte count remained zero in both groups until after the twentieth day, that is, after the time of death of the non-surviving animals.

The platelet count in surviving and non-surviving animals was so similar that it was thought that platelet

deficiency with its associated hemorrhages could not be considered a unique cause of death.

A third major factor which was examined was the occurrence of bacteremia in some of the fatally irradiated animals. This finding stimulated an investigation of the integrity of the reticuloendothelial system as a filter for bacteria. Injection of radioactive gold colloid showed no impairment by irradiation of the ability of the reticuloendothelial system to pick up inert particles.

Seven photomicrographs; 6 graphs; 2 tables.

DAVID C. GASTINEAU, M.D.
Indiana University

Whole Body Irradiation on the Healing of Fresh Fractures. August W. Spittler, Joseph W. Batch, and Ben A. Rutledge. Arch. Surg. **68**: 93–104, January 1954.

In a study of the effect of total-body irradiation on fracture healing, the author used 315 albino rats of the Wistar strain, of which 58 served as unirradiated controls. The remaining 257 were exposed to whole-body irradiation ranging from 300 to 900 r. The LD 50 for this strain is 500 r.

Under ether anesthesia each rat received a manual fracture of the left femur. The animals were then divided into two main groups: Group 1 had internal fixation of the fractures; Group 2 had no fixation. In Group 1 there were 166 rats, of which 35 were controls; in Group 2 there were 149 rats, 23 of which were controls. At weekly intervals a roentgenogram was made of the fractured femur and 1 animal from each subgroup and a control were killed and autopsied. The fracture site was examined for amount of callus and firmness of union, and a microscopic section was made of the fracture site.

The irradiated group showed weight loss, debility, and mortality which were proportionate to the dose of radiation. The greatest mortality took place during the first and second weeks. Only 2 animals receiving a usually fatal dose of radiation survived. Microscopically there was an alteration in the normal maturation and orderly development of cartilage and ossifying osteoid, resulting in a delay in healing of the fractures. Roentgenograms revealed that those animals with internal fixation (Group 1), both irradiated and controls, showed progressive union of their fractures. Those without internal fixation showed angulation at the fracture site, massive callus, and delayed calcification even at seven weeks.

It is concluded that, if rats survive the effects of the trauma of fracture and whole-body irradiation, repair of the fracture will be delayed but can be expected to progress to complete healing after the effects of irradiation have been overcome.

Three series of roentgenograms; 10 photomicrographs; 4 tables.

JOHN F. RIESSER, M.D.
Springfield, Ohio

Effect of X-Irradiation on Tissue Hydration in the Mouse. Roberts Rugh. Nucleonics **12**: 28–33, January 1954.

The purpose of the experiment described in this report was to measure the shift in water balance in various organs and tissues following whole-body x-ray irradiation. The importance of this is that nausea, vomiting, diarrhea, edema, fall in blood pressure, and shock all involve changes in hydration.

Swiss male mice were subjected to a 100 per cent lethal dose of x-rays (1,250 r). Three days after exposure, changes in the wet and dry weight and the percentage of water in ten separate organs as well as the carcass were measured. The mice were dissected rapidly after sacrifice and the organs were immediately weighed. The specimens were then dehydrated in an incubator and a desiccator.

In general, the shift in water balance was secondary to an almost universal decrease in dry weight of the various tissues studied. A significant observation was a pronounced increase in the amount of dry tissue in the brain and bone, muscle and carcass. Nervous tissue has usually been believed to be radioresistant. The complete data on all of the test animals are displayed in five tables.

JOHN S. LAUGHLIN, Ph.D.
Memorial Center, New York.

The Manner of Dependence of the "Permissible Dose" of Radiation on the Amount of Genetic Damage. H. J. Muller. Acta radiol. **41**: 5–20, January 1954.

In mice a dose of 80 r induces one mutation in a given gene in 50,000 gametes. If the same mutation rate applies to humans, an average per capita dose to the gonads of 80 r would probably result in a doubling of the spontaneous production of mutations. This, if allowed to continue indefinitely, would eventually cause "genetic death" (*i.e.*, death of an individual before reproduction) of 2 persons out of 5. It would also result, in the opinion of the author, in a 40 per cent reduction in the fitness of the average individual. The consequence would be a continued genetic deterioration and/or a continued decline in numbers.

According to the author, it should be the aim of all users of radiation to keep the exposure to the gonads to the lowest practicable level, both for patients and for those subject to occupational exposure. Before deciding whether or not to subject a patient to an exposure, there should be a balancing of all the benefit, or probability of benefit, against all of the damage, or probability of damage. However, in actual practice there is so much uncertainty on both sides that much intuitive judgment must be used. In most cases the question is not whether a given exposure should be made at all, but whether it is worth while to modify it, as for instance by special shielding, regulation of field and direction, scatter, voltage, and accompanying conditions, so that a smaller effective dose will be delivered to the gonads.

As a provisional measure, the author believes that it is advisable to limit the *average* per capita dose received before reproduction to about 20 r, that is to a dose which causes an increase in the mutation rate of 25 per cent. At 0.3 r per week, this dose would be received in sixteen months.

JOHN J. CRAVEN, M.D.
Cleveland Clinic

Conditions Which Affect the Biologic Damage Resulting from Exposure to Ionizing Radiation. L. H. Gray. Acta radiol. **41**: 63–83, January 1954.

The distribution of energy within cells exposed to ionizing radiation is determined by the type of radiation and cannot be altered by any means now known. However, various changes in the environment of cells can influence the damage resulting from irradiation. For many different types of radiobiological damage the effectiveness of a given dose of radiation is conditioned by the concentration of oxygen dissolved in the cell at the time of irradiation. The mechanism by which the

change in oxygen tension is brought about does not seem to matter. An increase in the oxygen tension renders the cell more sensitive, a decrease less sensitive. The author states that probably severe hypoxia during irradiation provides greater protection to animals than any other form of pre-treatment so far investigated.

Various chemical agents have been found to affect radiosensitivity. Cysteine has been found to be particularly effective. There is some evidence to indicate that the protection afforded by amines and amino acids is due to a lowering of the oxygen tension in the cells.

While most chemical treatments which affect radiosensitivity tend to protect the cell, an exception is found in carbon monoxide which, under certain conditions, increases the damage resulting from a given dose of radiation.

Physical agents may diminish or augment the ultimate damage resulting from irradiation. For example, exposure to infra-red light can increase the number of chromosome aberrations induced by roentgen radiation by as much as a factor of 3. Also, temperature manipulations can increase the survival rates of irradiated bacterial cultures.

It is interesting that the various chemical treatments which have been found to alter radiosensitivity are not effective if the radiation is of a type which produces a high ion density, *i.e.*, alpha particles and neutrons. Apparently, when the short-lived radicals produced by the radiation are formed very close together, they react among themselves in a manner quite different from that which obtains when they are more sparsely distributed. These differences in reaction profoundly affect the biologic changes which follow.

Eight diagrams. JOHN J. CRAVEN, M.D.
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The Amines and Particularly Cysteamine as Protectors Against Roentgen Rays. Z. M. Bacq. Acta radiol. **41**: 47–55, January 1954.

Some Remarks on Chemical Protection Against Ionizing Radiation. A. Forssberg. Acta radiol. **41**: 56–58, January 1954.

On Chemical Protection Against Ionizing Radiation. Z. M. Bacq. Acta radiol. **41**: 59–60, January 1954.

Various substances have been found which protect experimental animals and plants against the lethal effects of x-radiation. Outstanding among these protective agents are various amines, particularly cysteamine and cystamine. In experiments performed by Bacq, intraperitoneal injection of 3 mg. of cysteamine immediately before irradiation successfully protected 20-gm. mice receiving 700 r whole-body x-radiation. In a large series so treated, 97 per cent survived, as compared to only about 2 per cent of unprotected animals. Injection of cysteamine more than one hour before the irradiation, or after the irradiation, had no protective action. It was necessary to give 1,300 r to cysteamine-protected mice to obtain the same mortality rate as was produced in unprotected mice by 700 r.

Similar protective power was shown for cysteine in experiments by Forssberg with *Allium* roots.

The mechanism of the protective action of these amines is not clear. According to Bacq they apparently do not prevent damage from occurring but rather protect some regeneration factor, possibly coenzyme A. Protected mice surviving the irradiation do have destruction of the ovaries, thinning of the adrenal cortex, and graying of hair. They suffer a transient loss of weight, but quickly recover from this. There is a depression of the leukocyte count but this begins to rise on about the tenth day following irradiation.

At the University of Liege, cysteamine is now systematically used for protection of patients against radiation sickness (200 mg. intravenously injected up to 1 hour before irradiation). It is believed that this does not decrease the beneficial effect of the radiotherapeutic treatment. JOHN J. CRAVEN, M.D.
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Spontaneous and Induced Cell Restorations After Treatments with Ionizing and Non-ionizing Radiations. Raymond Latarjet. Acta radiol. **41**: 84–100, January 1954.

By the author's definition, "restoration" refers to successful treatment given following exposure to radiation and does not connote the mechanism by which the development of the lesion is modified. Natural restorations do occur. The author cites examples of spontaneous recovery in bacteria following ultraviolet irradiation and in diploid yeasts following alpha, beta, or roentgen irradiation.

Restoration is classified according to three types: (1) Restoration by reversion is the simplest of these. It consists of the deactivation of a molecule which has been activated by the radiation. Such a phenomenon is well established in crystals and high polymers and very likely could occur in the nucleoproteins of living cells. (2) Restoration by recovery consists of making up a deficiency of a cellular constituent which has been destroyed or inactivated by the radiation. This can be done either from an external supply or from within by favoring the synthesis of the deficient substance by the cell itself. (3) Restoration by superimposed injury consists of the destruction of a normal cellular metabolite which is required for the development of the lesion. Thus cutting the chain prevents the lesion from developing.

Temperature changes, either heating or cooling, can induce restorations and probably can act either through the mechanism of restoration by reversion or through restoration by recovery.

Akin to restoration by reversion is restoration by catalase, which is thought to proceed by knocking out some intermediate active compound in the chain of reactions which leads to the lesion, and thus preventing development of the lesion. The intermediate compounds affected by the catalase probably are organic peroxides.

Restoration by visible light, which can occur under certain conditions following irradiation with either ultraviolet light or ionizing radiations, is probably due, at least in some cases, to the mechanism of restoration by superimposed injury.

Three diagrams; 1 figure; 1 table.
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